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REPORT

OF

THE SUPERINTENDENT

OF THE

COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1864.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1866.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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IN THE HOUSE OF REPRESENTATIVES, *January* 13, 1865.

Resolved, That there be printed three thousand extra copies of the Coast Survey for 1864, two thousand for the use of the Coast Survey and one thousand for the use of the House.

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

THE REPORT OF THE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.

TREASURY DEPARTMENT, *December* 20, 1864.

SIR: I have the honor to transmit, for the information of the House of Representatives, a report by Professor A. D. Bache, Superintendent of the United States Coast Survey, showing the progress in that work during the year ending November 1, 1864; and also the manuscript map of progress brought up to the same date, as required by act of Congress, approved March 3, 1853.

I have the honor to be, very respectfully,

W. P. FESSENDEN,
Secretary of the Treasury.

Hon. SCHUYLER COLFAX,
Speaker of the House of Representatives.

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REPORT.

CAMBRIDGE, MASS., *October* 26, 1864.

SIR: I have the honor to submit, in conformity with the law and regulations of the Treasury Department, the following report on the progress made in the survey of the coast of the United States during the surveying year, which will end with the present month.

The general progress in the work under my superintendence has been summed up from time to time in previous reports. It is not now needful to recapitulate in detail, as our parties on southern sections of the coast are yet employed in local surveys to facilitate military operations, or for the use of blockading squadrons, in accordance with the policy adopted by the department at the outset of the rebellion. The large manuscript map, prepared under act of Congress of March 3, 1853, and as directed by the act, presented annually since that date, shows the progress up to the present time. In a general way the progress is shown also by the small engraved sketch (No. 37) which accompanies this report.

A brief statement of the work of the present year will be given to show the adaptation of the survey in all parts of its organization to the present requirements of the government service.

The war has not essentially changed the distribution of the working parties. About the same number as were heretofore assigned to duty on the southern coast has been in surveying service with the national forces in the rebellious States. Four parties have acted under the orders of Admiral Lee; three, with as many vessels, under Admiral Dahlgren, and two under Admiral Porter.

For the military service in Eastern Virginia and Maryland six parties were employed during parts of the season; in West Virginia three parties, at Knoxville two parties, at Nashville two, at Chattanooga five, previous to and during the movement on the rebel works at Missionary Ridge; two parties accompanied the army in Louisiana and Texas, and one was attached to the Florida tax commission.

From the several officers in whose commands the parties were associated warm acknowlegments have been reiterated as to the importance of the services rendered, and their bearing on the success of military and naval operations. The body of the report will contain, as usual, notices of the work in detail. Very brief mention will here be made of the localities and nature of this class of operations, and after it mention of the advance made in the regular progress of the survey of the coast.

SERVICE WITH ARMIES AND BLOCKADING SQUADRONS.

The survey has been kept in full co-operation with the blockading squadrons, and with the armies of the Union, as heretofore. In the vicinity of Baltimore the survey of ground connected with the defences has been continued by Sub-Assistant Iardella, and during part of the season by Assistant C. M. Bache. The topography of the approaches to the capital has been further extended beyond the northeast boundary of the District of Columbia, by Sub-Assistant Ferguson. A minute topographical survey has been made of Arlington Heights by Messrs. Hergesheimer and McMath for the War Department, and special determinations for the effective use of heavy artillery at Washington, New York, and Boston, by Assistant Schott. Sub-Assistant Donn is now engaged in surveying the approaches to the fords of the Potomac above and below Harper's Ferry. In West Virginia the latitude and longitude have been determined at eleven military posts by Assistant Dean and Sub-Assistant Mosman, and the magnetic variation at most of them by Mr. S. H. Lyman. At Clarksburg, Virginia, Mr. Lindenkohl assisted in compiling the military map of West Virginia, and computed the latitude of numerous points from the sextant observations of the late Lieutenant J. R. Meigs, formerly chief engineer of the department. Sub-Assistant Rockwell, before making a plane-table survey of Strawberry Plains and of the city of Knoxville and its defensive works, in which duty he was associated with Mr. R. H. Talcott, was engaged in similar service at Sewall's Point, Virginia. Assistant West, after reconnaissance duty, which terminated with the battle of Missionary Ridge, Tennessee, was in the same way employed at Bermuda Hundred, Virginia. Sub-Assistants Dorr and Donn made plane-table surveys of the environs and defences of Nashville and of Chattanooga, Tennessee, previous to the repulse of the enemy in the south approach to that city; and Mr. Donn, in conjunction with Mr. Marindin, afterwards rendered similar service for the army near Petersburg, Virginia. Sub-Assistant Boyd has made a complete survey of the battle-field of Chickamauga, Georgia, and is now under orders to rejoin the army at Chattanooga.

In connexion with the North Atlantic blockading squadron, Mr. Strausz, and subsequently Mr. Cordell, have made resurveys of the bar and channel into Beaufort harbor, North Carolina. The last-named officer sounded the harbor, and the entire channel which leads from Beaufort through the straits and through Core sound, marking also its course by buoys and stakes. The same parties reset the buoys between the bar and Fort Macon to conform to the changes found by the resurveys. Mr. Strausz also made a resurvey of Hatteras inlet, and sounded out a stretch of six miles of the Neuse river below New Berne, marking the channels in both localities by buoys. The triangulation of the Neuse river was at the same time continued by Assistant Fairfield. Sub-Assistant Halter made a triangulation and shore line survey of Croatan sound, and of Roanoke river, North Carolina, above and below Plymouth. These waters were thoroughly sounded by Sub-Assistant Bradford, and the channel through the latter was marked by spar-buoys. He has since sounded Trents' Reach, in James river, Virginia, and is now engaged in the survey of Bogue sound. A careful reconnaissance of the Cape Lookout shoals has been made by Lieutenant Commander Phelps with the surveying steamer Corwin.

Attached to the South Atlantic blockading squadron, and for service also with the military forces, three parties with the surveying steamer Vixen, and schooners Bailey and Caswell, were assigned. Assistant Boutelle, besides the complete development of the channels at present leading into Charleston harbor, in which also Assistant Edwards was engaged during part of the season, reset the buoys, and prepared new sailing directions. Under his direction Folly river and Light-house inlet have been sounded by Sub-Assistant Webber; the hydrography of Wassaw sound has been continued, and a resurvey made of the bar and channel of the St. John's river to a point near Mayport Mills. As heretofore, his party in the Vixen, in charge of Acting Master Platt, performed the pilot service required for the vessels of the South Atlantic squadron. Sub-Assistant Dennis made surveys for defensive works at Pilatka, Florida, extended the survey of the St John's river above Jacksonville, and during the military movements in that vicinity made a reconnaissance of the roads leading towards St. Augustine, Picolata, and Mayport Mills. At Port Royal he surveyed Bay Point and Land's End for naval purposes, and on Morris and Folly islands surveyed the shore lines of the inland passage between Light-house inlet and Folly river. Mr. McMath was on service with the United States tax commissioners for Florida, at Fernandina and at St. Augustine. He also furnished for military use a copy of the county map, showing the interior of Florida beyond Jacksonville.

In the military department of the Gulf, Assistant Oltmanns served on the staff of Major General Franklin, and made surveys along the route of the 19th army corps, including the environs of Vermilionville Opelousas, Washington, and Franklin, Louisiana. Sub-Assistant Hosmer was present with the army detachment at Aransas Pass, Texas, and located the position of the rebel works on a map, after determining the changes that had taken place in the depth of water on the bar of that pass. He performed similar duty at Pass Cavallo, traced and marked the changes which had occurred at the eastern end of Matagorda island, and buoyed the channel into McHenry bayou. After joining the staff of Brigadier General Grover, in January, Mr. Hosmer made surveys at Madisonville and Morganza, Louisiana, and at Fort Adams, Mississippi. Both of these officers accompanied the army of Major General Banks through the Red river campaign.

On the Mississippi river, and for the use of the squadron under Admiral Porter, Assistant Gerdes made a topographical survey of Grand Gulf and its vicinity, and sounded the channel abreast of that post. This was followed by a reconnaissance which included the shore and channel of about fifty miles of the course of the Mississippi, between Rodney and Vicksburg. He made also a minute survey of the Ohio river and its shores from Mound City to Cairo, Illinois, with soundings relative to inquiries concerning a navy yard site. Sub-Assistant Fendall assisted in this important survey, and was afterwards on duty with the gunboats which passed up Red river to act in concert with the land forces.

The transfer of some of these parties from one locality to another, as service required, has been noticed in the abstract just given; the transfer of others therein mentioned for prosecuting the usual work of the survey will appear in the short summary which follows.

GENERAL STATEMENT OF PROGRESS.

In connexion with the following summary, it should be borne in mind that many of the operations referred to under the preceding head have added to the material requisite for the usual publications of the survey.

In the northern sections of the Atlantic coast the regular operations of the survey have been continued, and the parties here enumerated are now at work: Sub-Assistant Dennis, in the topography of the lower part of Passamaquoddy bay, Maine; Assistant Fairfield, in coast triangulation near Mount Desert island; and Assistant McCorkle, in similar duty in Penobscot river, near Bangor; Sub-Assistant Dorr, in the topography of islands at the entrance of Penobscot bay; Sub-Assistant Ferguson, at the entrance of St. George's river, Maine; Assistant West, on the shores of Boothbay, Maine; Mr. McMath, on the east side of the Sheepscot river; Assistant Adams is completing plane-table work on the shores of the water passages which enter the Kennebec, near Bath, Maine; Assistant R. M. Bache, on the shores of the Kennebec, above Bath; and Sub-Assistant Longfellow, on the survey of islands on the east side of Casco bay. Sub-Assistant Webber has sounded the St. George's river, Maine, and its approaches; Mr. Strausz, the waters of Quohog bay, Maine; and Lieutenant Commander Phelps has extended the hydrography eastward of the approaches to Portland entrance. Assistant Mitchell has examined the known dangers to navigation in Eastport harbor and Muscle Ridge channel, (Penobscot bay,) and indicated the position of desirable aids to navigation. He has also continued work connected with the special survey of Boston harbor for the United States commissioners. The detailed survey of the shores of Narragansett bay is in progress by Assistant Harrison and Sub-Assistant Hosmer. On the coast of Connecticut the work of connecting the primary base lines in Sections I and II has been continued by my own party, and Assistant Blunt has extended the triangulation which connects the primary work with points on the Hudson river. The detailed topography of the shores of the Hudson has been extended by Assistant Whiting near Sing-Sing and Haverstraw. The hydrography near Sandy Hook has been re-examined by Assistant Mitchell, the results, as heretofore, having reference to the labors of the engineer department. Assistant C. M. Bache has been engaged at the highlands of Navesink, New Jersey. The work of verification on the coast of New Jersey has been extended by Assistant Farley to include Absecom inlet; the shores of Absecom harbor have been resurveyed by Mr. H. W. Bache, and the hydrography of the approaches and of the inlet executed by Lieutenant Commander Phelps. Assistant Mitchell made a special examination relative to the effect of the ice drift in the Delaware river during the winter of 1863–'64 for the Navy Department.

Tidal observations have been kept up at the permanent stations, at Eastport and Portland, Maine, Charlestown, Massachusetts, in New York harbor, and at Old Point Comfort; and magnetic observations at Eastport and Key West.

On the Pacific coast of the United States the triangulation along the Santa Barbara channel and between Monterey bay and San Francisco has been continued, and that of Suisun bay is in progress. The topography and in-shore hydrography between Point San Pedro and Tunitas creek have been completed, and a resurvey has been made of Mare Island strait, including the approaches to the navy yard.

The great enhancement of prices during the present year has unavoidably been felt in our operations. It is, however, a matter of gratification that the results here sketched compare favorably with those of the preceding years of the war. On the Pacific coast only has the progress of the work been sensibly retarded by the effect of the basis of currency in use there.

In office-work numerous direct calls have been met from generals and naval officers for tracings on the full scale of such sheets of the Coast Survey as were applicable to their purposes; these have been very generally found available in siege operations and in blockading service. Copies of maps for immediate use have in all cases been furnished to the naval and military commanders, to whose forces the parties have been attached. The tangible evidence of utility thus presented to a class of minds eminently practical has continued to elicit the warm commendation which marked our first connexion with the military and naval forces of the government at the outset of the war.

Of the regular charts of the Coast Survey nearly thirty-seven thousand copies have been distributed during the past year. In this aggregate are included twenty-three thousand copies which were supplied to the navy.

The compilation of maps for use in the armies and to illustrate their operations has been continued, and the several sheets include, on a uniform scale, by far the greater part of the area of the States in rebellion. The region embraced in the great campaign of Major General Sherman beyond Chattanooga was mapped at the office at his request, and by diligent exertion the sheets intended for the use of his army were completed and forwarded before the opening of the campaign.

The call from public officers in the civil and military service for this class of information has become general. Of all kinds, (excluding charts,) seventeen thousand copies have been distributed or sold during the year, the sales, as heretofore, reimbursing for the publication.

The descriptive memoirs of the southern coast, which were prepared at the outbreak of the rebellion, and intended for the exclusive use of naval and military commanders, retain their interest, and have been supplied, as heretofore, when calls were made for them.

OFFICE-WORK.

SECTION I. Sheet No. I, of a general chart of the Atlantic coast of the United States, scale 1:1,200,000, (Cape Sable to Sandy Hook,) has been drawn and engraved; a new edition of Nantucket shoals, with additions, has been prepared, and Rockland harbor, as a preliminary chart, has been completed. The drawing and engraving of coast charts No. 7, (Muscongus bay to Portland,) No. 8, (Seguin island to Kennebunkport,) No. 10, (Cape Ann to Plymouth,) No. 11, (Plymouth to Hyannis,) have been continued; progress has been made in the engraving of the charts of Kennebec and Sheepscot rivers, Barnstable harbor and Newport harbor. The drawing of Eastport harbor and approaches, and the drawing and engraving of a new edition of Boston harbor, embracing the resurvey for the harbor commission, have been commenced.

SECTION II. The drawing and engraving of a preliminary chart of Hudson river, sheet No. 3, (from Poughkeepsie to Troy,) have been completed; that of the finished chart of Hudson river, sheet No. 1, (from New York to Haverstraw,) and of coast chart No. 21, New York bay and harbor, (finished topography,) have been continued; and the drawing of a chart of Absecom inlet has been commenced.

SECTION III. A chart of Hampton Roads and Elizabeth river has been engraved. Progress has been made in the drawing and engraving of coast chart No. 28, (Cape May to Isle of Wight;) coast chart No. 29, (Isle of Wight to Chincoteague inlet;) Potomac river, sheet No. 1, (from the river entrance to Piney Point;) and Potomac river, No. 4, (from Indian Head to Little Falls.) The drawing of the general chart of Chesapeake and Delaware bays has been continued; that of a map of the approaches to Baltimore for military purposes has been commenced; additions have been made to the lithographic map of Virginia and southeastern Virginia; and a map of part of Virginia and North Carolina, on a scale of ten miles to the inch, has been drawn and engraved on stone.

SECTION IV. A preliminary chart of Cape Lookout shoals has been drawn and engraved; the drawing of additional surveys on coast charts Nos. 40 and 41, (Albemarle sound;) and a preliminary chart of the mouths of Roanoke river has been completed and the engraving commenced. Progress has been made in the engraving of coast chart No. 48, (Cape Fear and approaches,) and a tinted lithographic edition of the same has been printed for the use of the navy. New editions of the entrances to Beaufort harbor and Hatteras inlet, from resurveys, have been published.

SECTION V. The drawing and engraving of coast chart No. 53 (from Rattlesnake shoals to St. Helena sound) have been continued; and work on No. 54 (from St. Helena sound to Ossabaw sound) has been commenced. Progress has been made in the drawing and engraving of St. Helena sound, Port Royal sound, Beaufort river, South Carolina, and the inland passage from St. Helena to Port Royal sound through Harbor river, Stony river, and Station creek; and in the engraving of Wassaw sound, with the inland passage from Port Royal sound to Tybee Roads, through Skull creek and Calibogue sound. A new edition in tint of Charleston harbor, showing the resurvey of the bar, and a sketch of Light-house inlet, have been prepared. A military map of parts of Georgia and South Carolina has been drawn and engraved on stone.

SECTION VI. The engraving of the Atlantic coast, sheet No. 4, (Mosquito inlet to Key West, including the Bahama banks,) of the western end of Florida reefs, including Tortugas islands, of a new edition of Key West harbor, and of additions to general coast chart No. X, (straits of Florida,) has been completed. Progress has been made in the drawing and engraving of coast chart No. 69, (Florida reefs, from the Elbow to Matecumbe key,) and of No. 70, (Long key to Newfound Harbor key.) A preliminary chart of the main entrance to Charlotte harbor, Florida, has been commenced, and a military map of the northern part of Florida has been drawn and engraved on stone.

SECTIONS VII, VIII, and IX. A general chart of the Gulf coast, from Key West to the Rio Grande, has been drawn and engraved; the engraving of coast chart No. 100 (Point au Fer to Marsh island, Louisiana) has been continued, and additions have been made to coast chart No. 108, (Matagorda and Lavacca bays, Texas.) A new edition of Mobile bay and approaches has been prepared in tint; maps of the approaches to Vicksburg and Grand Gulf, Mississippi; and of the Mississippi river and its shores from Rodney to Palmyra bend; and military maps, embracing the States of Mississippi, Alabama, and part of Georgia, on a scale of ten miles to the inch, have been drawn and engraved.

SECTIONS X and XI. The drawing and engraving of Tomales bay, as a finished chart, and of Half Moon bay, as a preliminary chart, have been completed. Progress has been made in the drawing and engraving of Bodega bay, upper part of San Francisco bay, and chart of the Pacific coast from Point Pinos to Bodega Head. A new edition has been prepared of Washington sound, with additions and corrections, and additions have been made to the other plates previously engraved.

MAPS AND CHARTS.

In the regular progress of the work of publication, many of the early sketches and preliminary editions of charts, issued to make the information obtained by the survey available to the public as soon as practicable, are superseded by or absorbed in the more finished charts, which are prepared as the information accumulates, especially those which embrace the whole coast in a connected series, on a scale of $\frac{1}{80000}$. This process must be kept in mind when following the reported advance of various maps and charts from year to year, and in comparing the catalogue of charts (Appendix No. 10) now issued by the Coast Survey Office to the government vessels, or sold to the commercial marine, with annual statements of plates engraved. Thus a chart of an important locality will be first published with the bare shore-line, soundings, channel curves, and sailing directions—an incomplete form—but still containing the information most important for the navigator. While an electrotype copy of this plate is used for printing, the engraving of the original is continued; the shoals are made conspicuous by sanding; other hydrographic details are added as they are developed by the survey; and the outlines of the topography are engraved, bringing the map to a second stage, in which it is again issued, superseding the first, but still remaining a preliminary edition. This also is printed from electrotype copies, while the original is receiving the finished representation of topography, as hills, woods, fields, marsh, &c., together with views, and all requisite notes and tables, so as to form at length the finished map, which alone is retained in the catalogue.

Seventy-four sheets have been worked upon in the drawing division within the past year. Fourteen of this number were first-class maps and charts of large size; eight first-class, and twenty-four preliminary harbor charts and sketches; twelve sheets were intended for engraving on stone, or for photographic reduction, and sixteen were progress sketches. Fifty-six sheets have been completed, and eighteen are in progress. Of the hydrographic sheets completed, two are large charts of the coast series, and twenty-six harbor charts, most of which were for issue in preliminary form.

In the engraving division two first-class maps and charts have been completed within the year. Eight plates of second-class charts and sketches have also been engraved, and two diagrams. Nine preliminary editions have been engraved preparatory to their final completion. Twenty-three plates are now in progress, of which five were commenced within the year. This gives a total of twenty-four plates completed, and twenty-three in progress, or forty-seven plates worked upon during the year.

All the details in regard to the production and distribution of maps and charts will be found in the report of the assistant in charge of the office. (Appendix No. 10.)

The following is a list of charts arranged in geographical order which are either the result of the present season's work, or, having been heretofore prepared, have not yet appeared in any annual report, for reasons of public policy, although issued to public vessels. Such of this number as it may be deemed expedient to publish at the time will appear with this report, as will some others which have not heretofore been published in any annual report in the present finished state, viz: the three sheets of Long Island sound, and the upper three sheets of Chesapeake bay, together with the necessary sketches, to illustrate the progress of the survey:

Eastport harbor, Maine.
Rockport and Camden harbors, Maine.
St. George's river, Maine.
Kennebec and Sheepscot rivers, with Boothbay harbor, Maine.
Lynn harbor, Massachusetts, resurvey of 1864.
Boston bay and approaches, coast chart No. 1, (preliminary edition.)
Bristol bay, Rhode Island.
Newport harbor, Rhode Island.
Absecom inlet, New Jersey.
Potomac river, sheet No. 1, from the entrance to Piney Point.
Potomac river, sheet No. 2, from Piney Point to Lower Cedar Point.
Potomac river, sheet No. 3, from Lower Cedar Point to Indian Head.
Potomac river, sheet No. 4, from Indian Head to Little Falls.

James and Appomattox rivers, from City Point to Richmond and Petersburg.
Albemarle sound, eastern part, coast chart No. 40, (new edition.)
Albemarle sound, western part, coast chart No. 41, (new edition.)
Mouths of Roanoke river, North Carolina.
Core sound, North Carolina.
Cape Lookout shoals, North Carolina.
Cape Fear and approaches, with the river to Wilmington, North Carolina, coast chart No. 48.
Charleston bar, resurvey of 1864.
Light-house inlet, and inland passage to Folly river, South Carolina.
Stono inlet, South Carolina.
Coast of South Carolina, from Rattlesnake shoals to St. Helena sound, coast chart No. 53.
Coast of South Carolina and Georgia, from St. Helena sound to Ossabaw sound, coast chart No. 54.
Beaufort river, Station creek, Story and Harbor rivers, with inland passage between Port Royal and St. Helena sounds, South Carolina.
Port Royal entrance, South Carolina, survey of 1863.
Calibogue sound and Skull creek, forming the inland passage between Tybee roads and Port Royal sound, South Carolina.
Wassaw sound, with Wilmington and Tybee rivers, Georgia.
Ossabaw sound, Georgia.
Sapelo sound, Georgia.
Altamaha sound, Georgia.
St. Simon's sound, Georgia.
Charlotte harbor, Florida.
Mississippi river, reconnaissance from Rodney to Palmyra bend, Mississippi.
Ohio river, from Mound City to Cairo.
Western coast of the United States, from San Diego to Point Reyes.
Western coast of the United States, from San Francisco to Umpquah river.
Western coast of the United States, north of Umpquah river.
Pacific coast, from Point Pinos to Bodega Head.
San Francisco bay, upper part.
A list is given, at the close, of such of these charts and others that are intended to accompany this report.

ESTIMATES.

The estimates here submitted are designed to carry forward the work required on the eastern part of the Atlantic coast, and to provide for the progress which may be feasible on the southern part and in the Gulf; to continue the work on the Pacific coast, and to provide for the assignment of special parties as heretofore, with the concurrence of the department, for service with the fleets and armies.

The estimates for progress on the Atlantic, Gulf coast, Florida reefs, and western coast of the United States, are given, as usual, in separate items, and are exclusive of the aid formerly, but not now, extended for the work, by the detail of officers of the army and navy.

Estimates in detail.

For general expenses of all the sections, namely, rent, fuel, materials for drawing, engraving, and printing, and for transportation of instruments, maps, and charts; for miscellaneous office expenses, and for the purchase of new instruments, books, maps, and charts $19, 000

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.* FIELD-WORK.—To continue the triangulation of *Passamaquoddy bay,* and to extend it so as to include the north-eastern boundary along the *St. Croix river;* to complete the secondary triangulation of the coast of Maine east of *Mount Desert island;* to continue the topography of *Passamaquoddy bay* and its dependencies; to complete that of *Prospect harbor,* and commence that of *Goldsborough bay,* (coast of Maine;) to continue that of the islands at the entrance of *Penobscot bay,* and the western shore of the bay above *Camden,* and that of the adjacent shores of *Muscongus sound;* to complete the topography of the *Damariscotta river,* and of the eastern shore of the *Sheepscot river,* and to complete the survey of the eastern shores of *Casco bay;* to continue the detailed survey of the shores and islands of *Narragansett bay;* to continue off-shore soundings along the coast of Maine, and the hydrography of *Passamaquoddy bay, Frenchman's bay,* and approaches of *Penobscot bay,* and *Goldsborough, Prospect* and *Winter harbors;* to continue tidal and magnetic observations at Portland, and tidal observations in the progress of the hydrography. OFFICE-WORK.—To make the computations required for and reductions from the field observations; to continue the drawing of coast chart No. 1, *Passamaquoddy bay;* to continue the drawing and engraving of coast chart No. 6, approaches of *Penobscot bay;* of No. 7, *Pemaquid Point to Cape Elizabeth;* of No. 8, *approaches to Casco bay;* of No. 10, coast of Massachusetts, from *Cape Ann to Plymouth,* and of No. 14, *Narragansett bay and approaches;* to continue the drawing and engraving of general coast chart No. 1, *Quoddy Head, Me., to Cape Cod, Mass.;* to complete the drawing and engraving of charts of *Eastport harbor and Rockland harbor;* to continue the drawing and engraving of *Winter harbor, Rockport, and Camden harbors, and Tennant's harbor;* and of *Herring Gut* and *St. George's river* and approaches; of the *Damariscotta river* and of *New Meadow harbor;* and to complete the drawing and engraving of charts of the *Sheepscot river, Me.,* of *Newport harbor,* and of *Providence river, R. I.,* and to engrave the resurvey of *Boston harbor,* will require.. $62, 000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.* FIELD-WORK.—To complete the observations required for connecting the *Epping base,* in Section I, with the *Fire Island base,* in Section II; to continue the triangulation of *Connecticut river,* between Higganam and Hartford, and that of the *Thames river,* above New London; to continue verification work on the *coast of New Jersey,* south of Absecom inlet; to continue the topography of the shores of the *Connecticut* and *Thames rivers,* and the detailed survey of the shores of the *Hudson,* above Haverstraw; to execute such supplementary hydrography as may be required in *New York bay* and *Delaware bay;* to continue the tidal observations. OFFICE-WORK.—To make the computations and reductions; to continue the engraving of coast chart No. 21, *New York harbor,* and its approaches, (new edition;) and to commence the drawing and engraving of coast chart No. 22, from *Sandy Hook* to *Barnegat;* to continue the drawing and engraving of sheet No. 2, of the chart of *Hudson river,* (from Haverstraw to Poughkeepsie;) and of a chart of the *Connecticut river:* and to complete the engraving of coast chart No. 28, from Cape May, N. J., to Isle of Wight, Del., will require.. 17, 500

SECTION III. *Coast of part of Delaware and that of Maryland, and part of Virginia.* FIELD-WORK.—To continue astronomical and magnetic observations in the section, and secure the stations of the triangulation; to make extensions of the triangulation for including the detached plane-table surveys in the vicinity of *Washington city;* to complete the topography near *Washington,* required for defensive purposes, and continue that of the eastern shore of Virginia; to make such detailed surveys as may be necessary at points on the *Potomac, Rappahannock,* and *James rivers;* and to continue the off-shore hydrography and tidal observations in the section. OFFICE-WORK.—To make the computations from field-work; to draw maps of the approaches to *Baltimore* and *Washington;* to continue the engraving of coast chart No. 29, (from *Isle of Wight, Del.,* to *Chincoteague, Va.,*) and of No. 30, from *Chincoteague* to *Great Machipongo inlet, Va.;* to continue the engraving of coast chart No. 30 *bis, (Chesapeake entrance,)* and general coast chart No. IV, *(approaches to Delaware and Chesapeake bays;)* and to commence the drawing and engraving of a chart of *James river, from Newport News to City Point,* will require.. 14, 500

SECTION IV. *Coast of part of Virginia and part of North Carolina.* FIELD-WORK.—To complete, if practicable, the primary triangulation of *Pamplico sound,* and make the requisite astronomical and magnetic observations; to continue the triangulation of *Pamplico river;* to continue the triangulation and commence the topography of the shores of *Neuse river;* to complete the topography of the outer coast of *North Carolina,* between *Hatteras inlet* and *Core sound;* to continue the in-shore and off-shore hydrography in the vicinity of *Cape Lookout;* and to execute that of *Pamplico river,* and such other soundings as may be required in the waters of *Pamplico* or *Albemarle sounds;* to make observations of the tides and currents. OFFICE-WORK.—To make the computations and reductions; to commence the drawing and engraving of general coast chart No. V, from *Cape Henry* to *Cape Lookout;* to continue the engraving of coast chart No. 38, (from *Currituck, Va.*, to *New inlet, N. C.;*) and of coast charts Nos. 46 and 47, (from *Cape Lookout* to *Barren inlet;*) and the drawing and engraving of a chart of the *Neuse river;* and to complete the engraving of coast chart No. 48, *Cape Fear and approaches*, will require $15,000

SECTION V. *Coast of part of North Carolina and that of South Carolina and Georgia.* FIELD-WORK.—To execute such triangulation and topography as may be practicable in places not yet embraced in the survey; to execute the hydrography that may be required, and additional soundings in the shifting bars in this section, with tidal observations. OFFICE-WORK.—To continue the engraving of coast chart No. 53, (from *Rattlesnake shoal to St. Helena sound, S. C.;*) to continue the drawing and engraving of No. 54, (from *Fripp's inlet, S. C.*, to *Ossabaw sound, Ga.;*) to continue the drawing of No. 57, (from *Sapelo sound* to *St. Andrew's sound, Ga.,*) and that of general coast chart No. VII, (from *Winyah bay, S. C.*, to *St. John's river, Fla.,*) and continue the engraving of the last-named chart; the resurvey of *Charleston harbor* entrance, and the drawing and engraving of the *inland passage* between St. Helena and Port Royal sounds, S. C., and of *Wassaw sound, Ga.*, will require 17,000

SECTION VI. *Coast keys and reefs of Florida.*—(See estimates of appropriation for these special objects.)

SECTIONS VII, VIII, and IX. *Part of the western and northern coast of Florida and the coast of Alabama, Mississippi, Louisiana, and Texas.* FIELD-WORK.—To execute such triangulation, topography, and hydrography, in continuation of the surveys in these sections, as may be practicable, and such special surveys as may be required for public service. OFFICE-WORK.—To continue the computations and reductions of previous field-work; to continue the engraving of coast charts Nos. 84 and 85, (western coast of Florida from *Ocilla river to Cape St. Blas;*) the drawing of No. 96, *(delta of the Mississippi,)* and that of general coast chart No. XIV, (north-eastern coast of the *Gulf of Mexico;*) to continue the engraving of the last-named chart, and to commence the engraving of general coast chart No. XVI, (western coast of the *Gulf of Mexico,*) will require 36,000

Total for the Atlantic coast and Gulf of Mexico $181,000

The estimates for the Florida coast, keys, and reefs, and for the western coast of the United States, (California, Oregon, and Washington Territory,) are intended to provide for the following purposes:

SECTION VI. *Coast, keys, and reefs of Florida.* FIELD-WORK.—To continue, if practicable, the survey of the eastern coast of the peninsula south of the present limit at *Matanzas inlet*, or north of Indian river; to complete the triangulation of keys inside of the Florida reefs and between *Chatham bay* and *Cape Sable;* to continue the topography of those in *Chatham bay*, and complete that of *Charlotte harbor;* to complete the hydrography of the approaches to that harbor, and run off-shore lines of soundings from the reef and from the coast of this section; to continue magnetic observations at *Key West*, and such tidal observations as may be requisite. OFFICE-WORK.—To compute the results of field-work; to complete the drawing and engraving of coast charts Nos. 69 and 70, *(Florida reefs*, from the Elbow to Newfound Harbor keys,) and general coast chart No. X, *(Florida reefs*, from Key Biscayne to the Marquesas;) and to continue the drawing and engraving of a chart of the approaches to *Charlotte harbor*, will require $11,000

SECTION X. *Coast of California.* FIELD-WORK.—To continue the coast triangulation southward of the *San Pedro base*, or northward of *Santa Barbara*, and the work for connecting the *Santa Barbara* islands by triangulation with the coast of California; to continue the triangulation northward from *Bodega*, and to execute that of *Suisun bay;* to continue the topography of the islands in *Santa Barbara channel*, that of the shore of *Bahia Ona*, that of the coast north of *Bodega Head*, and to complete that of *Suisun bay;* to complete the hydrography of *Suisun bay;* to run off-shore lines of soundings from the principal headlands of the section; to extend the in-shore hydrography northward of *Bodega*, and re-examine bars subject to change in *San Pablo bay;* to continue tidal observations at *San Diego* and *San Francisco.* OFFICE-WORK.—To make the computations from field-work; to complete the drawing and engraving of a chart of *Half-moon bay*, the engraving of the resurvey of *Mare Island straits*, and of the upper sheet of *San Francisco bay*, and of a chart of *Suisun bay;* to continue the drawing and engraving of a general coast chart of the Pacific, (from *San Diego to Point Conception,*) and of a chart of *San Francisco bay,* to be issued in one sheet.

Also, for the operations in—

SECTION XI. *Coast of Oregon and that of Washington Territory.* FIELD-WORK.—To make the astronomical and magnetic observations required in this section, or in Section X; to continue the triangulation of *Washington sound* in connexion with former work, and to make such plane-table surveys in continuation of previous work as may be practicable; to continue the hydrography in *Admiralty inlet,* or execute soundings in such special localities of *Oregon or Washington Territories* as may be called for by public interests; to continue tidal observations at Astoria, and make such as may be required by the hydrography. OFFICE WORK.—To continue the computations of field-work; to continue the drawing and engraving of surveys, as far as now made, for charts of *Koos bay, Gray's harbor, Washington sound, Admiralty inlet,* and *Puget's sound,* will require $100,000

The two small items following are in terms and amount the same as were asked for last year, and the third one is diminished in amount in consequence of a less number of steamers in use:

For publishing the observations made in the progress of the survey of the coast of the United States, per act of March 3, 1843 4,000

For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853 4,000

For pay and rations of engineers for three steamers to be used in the hydrography of the Coast Survey, and no longer supplied by the Navy Department 6,000

The amounts thus estimated for the fiscal year 1865–'66, and the appropriations for the present year, are here given in parallel columns.

Object.	Estimates for fiscal year 1865–'66.	Appropriated for fiscal year 1864–'65.
For survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	$181,000	$178,000
For continuing the survey of the western coast of the United States, including compensation of civilians engaged in the work, per act of September 30, 1850	100,000	100,000
For continuing the survey of the Florida reefs and keys, including compensation of civilians engaged in the work, per act of March 3, 1849	11,000	11,000
For publishing the observations made in the progress of the survey of the coast of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	4,000	4,000
For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853	4,000	4,000
For pay and rations of engineers for three steamers used in the hydrography of the Coast Survey, no longer supplied by the Navy Department	6,000	*9,000
Total	306,000	306,000

*Formerly included in estimates of the Navy Department.

DEVELOPMENTS AND DISCOVERIES.

Under this head are included the special results of hydrographic operations, and in some cases of the topography. The particular localities in which developments were made by the hydrographic parties within the present year are stated below. The items are supplementary to the general list given in Appendix No. 4, in which the previous developments and discoveries made in the progress of the survey are arranged in geographical order.

1. Determination of the position of Birch Point ledge, with eleven feet of water in it, in Wiscasset bay and of a rock with only four feet, near Clou's ledge, in Sheepscot river, Maine.

2. White Head ground, about eight miles to the eastward of Cape Elizabeth, Maine, developed in its general direction.

3. A rock in the entrance of New Bedford harbor, Massachusetts, determined in position.

4. Development of Round shoal, with eleven feet at mean low water, outside of the four-fathom curve off Absecom inlet, New Jersey.

5. Hatteras inlet. The character and extent of recent changes in the depth of water determined by resurvey.

6. Three separate shoals developed by reconnaissance to the south and eastward of Cape Lookout, North Carolina.

7. Beaufort harbor, North Carolina, re-examined, and its hydrographic changes determined.

8. Two new channels developed, leading into Charleston harbor, South Carolina, resulting from changes in the direction of the former channels and shoaling in the Lawford channel.

9. Hydrographic changes determined at the bar and in the channel of St. John's river, Florida.

10. Mare Island strait resurveyed, and changes developed in the vicinity of the navy yard.

11. Special examination of the flat in San Pablo bay, between San Pablo and Pinole Point.

SPECIAL SURVEYS.

The physical survey of Boston harbor has been continued under my direction by Assistant Henry Mitchell. Most of the work of the present season was confined to the tabulation and arrangement of data needed by the commission, authorized to advise in regard to the preservation of the harbor. The commission, as stated in previous reports, consisted of the late Chief Engineer, General Joseph G. Totten, Admiral C. H. Davis, and myself. The expenditures for the work, as heretofore, have been defrayed by the city authorities of Boston.

At the request of the Navy Department a special examination was made in the course of last winter as to the effect of floating ice in two localities of the Delaware river, which had been under consideration as sites for a navy yard.

Numerous surveys which might be noticed under this head, being specially called for by generals in command of armies in the field, will be mentioned under the heads of sections in the report corresponding to the localities of the work.

TIDE TABLES FOR MARINERS.

The tide tables for the use of navigators are given in a revised form in Appendix No. 8. In addition to the usual number printed with the annual report, one thousand copies were prepared in pamphlet form during the first year of the war. These have been distributed from the Coast Survey office or from the Naval Observatory for the use of government vessels.

The mean interval between the time of the moon's transit and the time of high water at Old Point Comfort is corrected in the tables of this year from the latest observations.

A report on the field and office work connected with tidal stations is given in Appendix No. 9, and the office occupation of the tidal division in Appendix No. 10. With the former is included a general description of the peculiarities observed in the tides at Tahiti, the largest of the Society islands in the South Pacific ocean.

INFORMATION FURNISHED.

A list showing special items of information furnished from the office during the year is given in Appendix No. 2. While calls arising in the ordinary course of enterprise have been lessened, those connected with military and naval operations have largely increased. Besides the items given in the list, numerous applications belonging to the same general class, but more local in character, have been answered at the office.

The regulation of the department requiring acknowledgment in the title of any publication embodying information procured from the Coast Survey office has been strictly observed.

In addition to the matter usually given under this head, assistance has been rendered to the artillery department of the army for the determination of ranges of ricochet gunnery with fifteen-inch and twenty-inch guns. The experiments were made under the direction of General A. P. Howe, inspector of artillery United States army, and the operations for measuring the ranges of each impact of the projectile are stated at length in the Appendix, Nos. 21 and 22, by Assistant Schott. He also furnished a set of equations determining the trajectory of ricochet shot, and applied them in practice to illustrate their use. Mr. Schott visited two batteries on the Potomac, three forts in New York harbor, and one in Boston harbor, where the necessary measurements were taken. At each of these places temporary frameworks were erected, and the range lines were marked for given lines of fire.

GEOGRAPHICAL POSITIONS.

In Appendix No. 15 the publication of geographical positions is resumed in part, in continuation of similar lists given biennially in my report for 1859 and preceding years. The register of positions on the southern coast is still reserved in the office. The total number of positions thus far given in latitude and longitude deduced from the triangulation is eight thousand two hundred and seventeen. Any small differences between the publications since the year 1851 are due to the effect of later and accumulated material, geodetic and astronomical, which has been brought to bear on the results.

GEODESY.

The geodetic connexion of the Epping base line with the primary triangulation passing through the eastern States, offers so instructive an example of the process of reduction followed in the computations of the Coast Survey, and of the application of the method of least squares, that I have given in full Assistant Schott's report on the subject, in Appendix No. 14; that paper may be regarded as an extension of Appendix No. 33 S, in my annual report for 1854. It exhibits the combination of resulting angles from measures of directions and from measures of angles by repetition, and assigns the relative weights to the results. The residuals in the sum of the angles of the triangles are shown, and proper weights are given to the conditional equations depending upon the closing of the triangles as well as (primarily) upon the probable errors of the measured directions or angles. The thirty-five normal equations were solved by the indirect method of elimination.

The report by Mr. Schott concludes with a statement of the resulting angles and computations of the sides of the triangles.

It is proper to remark that the length used for the Epping base in this report, though very nearly so, is not the final length, which can be deduced only from certan comparisons that remain to be made.

LONGITUDE.

The computations for the longitude of American stations from the European meridian, by Pleiades occultations, have been continued under the direction of Professor Benjamin Peirce, of Harvard, according to the comprehensive plan developed by him, and before alluded to in my annual reports. His remarks (Appendix No. 11) give such promise of agreement in results as will justify the expectations founded on the adoption of the method.

The computations of differences of longitude between American stations, determined heretofore by the telegraphic method, have been continued by Dr. B. A. Gould. In addition to the results formerly reported, the longitudes of Raleigh, N. C., Wilmington, N. C., and Columbia, S. C., have been definitely settled, giving a total of twelve stations determined in longitude south of Washington. The report of Dr. Gould is given in Appendix No. 12.

The telegraphic difference of longitude between New York and Washington, deduced some years ago without the advantage of recent improvements in instruments, is somewhat uncertain. There is also a small geodetic difference which enters into that determination. It is, therefore, desirable that the telegraphic method should be again applied for a new determination of the difference of longitude between the two cities.

The list of fundamental star places, used in longitude determinations, has been submitted to a new discussion, and the declinations of the time star list have also been determined.

The investigation of the diurnal motion in azimuth of the transit instruments has been continued, and new results found strongly confirmatory of previous inferences. This subject is receiving attention in other quarters. Hereafter it must be brought into the determination of star places in order to obtain the best results practicable.

MAGNETISM.

The series of papers containing a discussion of the magnetic observations made at Girard College, Philadelphia, from 1840 to 1845, contained in some of the preceding annual reports, is brought to a close this year by the insertion of the last three parts, Nos. X, XI, and XII, contained in the Appendix, Nos. 16, 17, and 18. To facilitate the reference to the separate parts, I herewith give an abstract of the headings and general contents:

SECTION I.—Part I—Coast Survey report, 1859, Appendix No. 22—Investigation of the eleven (or ten) year period in the amplitude of the solar-diurnal variation, and of the disturbances of the magnetic declination. Part II—Coast Survey report, 1860, Appendix No. 23—The solar-diurnal variation in the magnetic declination and its annual inequality. Part III—Coast Survey report, 1860, Appendix No. 24—Influence of the moon on the magnetic declination.

SECTION II.—Part IV—Coast Survey report, 1862, Appendix No. 15—Investigation of the eleven (or ten) year period, and of the disturbances of the horizontal component of the magnetic force. Part V—Coast Survey report, 1862, Appendix No. 16—Solar-diurnal variation and annual inequality of the horizontal component of the magnetic force. Part VI—Coast Survey report, 1862, Appendix No. 17—Lunar influence on the magnetic horizontal force.

SECTION III.—Part IV—Coast Survey report, 1863, Appendix No. 19—Investigation of the eleven (or ten) year period, and of the disturbances of the vertical force; with appendix on the effect of the aurora borealis on the magnetic declination and on the horizontal and vertical force. Part VIII—Coast Survey report, 1863, Appendix No. 20—Solar-diurnal variation and annual inequality of the vertical component of the magnetic force. Part IX—Coast Survey report, 1863, Appendix No. 21—Lunar influence on the magnetic vertical force, the inclination and total force.

SECTION IV.—Part X—Coast Survey report, 1864, Appendix No. 16—Analysis of the disturbances of the dip and total force. Part XI—Coast Survey report, 1864, Appendix No. 17—Solar-diurnal variation and annual inequality of the inclinationand total force. Part XII—Coast Survey report, 1864, Appendix No. 18—Discussion of the magnetic inclination and table of absolute values of the declination, inclination, and intensity between 1841 and 1845.

I proceed to a more detailed account of the contents of the three parts contained in this volume:

Part X (Appendix No. 16) analyzes the disturbances of the dip and total force. The instrumental quantities given are the differential readings of the horizontal and vertical components of the magnetic force expressed in scale divisions, and corrected for progressive change and effect of changes of temperature. Each entry was marked as a disturbance that differed as much as, or more than, ± 30 scale divisions from the normal of the vertical force, and as much as, or more than, ± 33 scale divisions from the normal of the horizontal force, and was transcribed and converted into its equivalent part of the respective force. When but one of the components was disturbed, the contemporaneous value of the other component was also inserted; a chronological table of the disturbances of the two components was thus formed, and the corresponding values of differences from the normal dip, (expressed in minutes of arc,) and from the total force, (in parts of that force,) were computed by their well-known geometrical relations. By an extended use of the criterion $\pm 1'.1$ was recognized as the limit, beyond which the disturbed values of the dip commence, and ± 0.00094 parts of the force as the corresponding limit of the total force disturbances. There remained, then, for discussion 1,446 disturbances of the dip. The first two tables contain the aggregate amount and number of disturbances of the dip for each month, divided into those which increase and those which decrease the dip; also the resulting monthly ratios and laws of progression. The next two tables exhibit the changes due to the eleven-year period, in the aggregate amount and number of disturbances, for increasing and decreasing values. The diurnal inequality of the disturbances is next shown for the aggregate amount and number, and the law of progression is exhibited for both, increasing and decreasing inclination, together with the average diurnal effect. The hours of maxima and minima, and the degree of correspondence or divergence in each case, are pointed out. Disturbances increasing the dip, upon the whole, preponderate. A table of disturbances, distributed according to their size, concludes this part of the inquiry. The disturbances, 1,470 in number, of the total force are next taken up and treated in precisely the same manner as those of the dip, and their annual and diurnal distribution, and change for the eleven-year period, are shown by means of ratios. This part concludes with tables of the average diurnal effect, and of the distribution of the disturbances of the total force according to their size. Whenever practicable, comparisons of these rather intricate laws of the disturbances with corresponding ones, deduced from the Toronto observations, are instituted and commented upon.

Part XI (Appendix No. 17) treats of the solar diurnal and annual inequality of the dip and total force. The combination of the two experimental components to form the dip and total force was effected as follows: Owing to the eleven-year inequality contemporaneous readings only, of the two parts, can be admitted for combination. The observations of the horizontal force from July, 1840, to July, 1841, are therefore here omitted. By means of a preceding paper (Part V) a table was made out of hourly values (expressed in scale divisions, corrected for progressive and temperature changes, and freed from the larger disturbances) of the horizontal force; each value was compared with its corresponding monthly normal, and the difference converted into parts of the force. The same was done with respect to the vertical force, by means of numbers, given in Part VIII. The differential values, expressed in minutes of arc, for the dip, and in parts of the force for the total force, were then computed by the formulæ, connecting these elements with their components. The semi-annual inequality of the dip, found by comparison of the summer and winter means with the annual means, has its turning epochs about the middle of April and October. 5½ a. m., 1 p. m., 3 p. m., and 7 p. m. are hours of no semi-annual change; greatest change at 10 a. m.; secondary change at 6 p. m.; range 0.′51 and 0.′18 respectively. The diurnal inequality of the dip is shown analytically and graphically for each month, also for the summer and winter half year, and for the whole year. The general character of the last curve shows a maximum about 11 a. m., and a minimum about 5 a. m., with a range of 1.′2. In summer these epochs occur earlier, range 1.′5, and in winter later, range 1.′0. There is also a secondary maximum and minimum. The diurnal range of the dip is greatest about the time of the equinoxes, less in winter, greater in summer. The afternoon minimum disappears about the time of the equinoxes, and is best marked about the time of the solstices. Principal epochs of the normal dip, when best marked, are *7h. 22m.* a. m. in summer, *8h. 33m.* a. m. in winter, and *7h. 50m.* a. m. for the whole year. The semi-annual inequality of the total force has its turning epoch about the 4th of April and 12th of September. 6 a. m. and 7 p. m. are hours of no semi-annual range; greatest change about 2 a. m. and 4 p. m.; range 0.00037 and 0.00033 parts of the force. The diurnal inequality of the total force consists of a single crested curve, on the average, during the year, but in winter it assumes a double progression. The principal maximum in summer occurs about 2 p. m., and in winter one hour and a half earlier; the principal minimum in summer occurs about 10 p. m., and in winter two hours earlier. Summer range nearly 0.0009; winter range nearly 0.0004 parts of the force. The hours 6½ a. m. in summer and 7½ a. m. in winter are epochs of normal total force. The paper concludes with an attempt to deduce the annual inequality of the dip and total force, and is illustrated with several diagrams. (Sketch No. 38.)

Part XII (Appendix No. 18) contains the results and discussion of the observations for dip, obtained with a Robinson dip circle, the same instrument which was employed in the magnetic survey of Pennsylvania and adjacent States. The series commence in January, 1842, and terminate in July, 1844; the observations were made weekly. There are, however, some breaks. Needle No. 1 was employed, with but a few exceptional cases, throughout the series; the casual results by three other needles have been referred, by comparison, to this standard needle. The monthly and annual mean dips are tabulated, the latter indicating an annual decrease of 1.′2. There is also a collection of dip results, taken at Philadelphia, compiled from various sources, and properly arranged. By grouping these the secular change of the dip is expressed by a formula involving the time and square of the time. A comparison of the observed and computed dips assigns a probable error of $\pm 4'.8$ to each represented value. The minimum dip occurs about January, 1840. The discussion closes with a table of magnetic constants for five epochs, and for the mean epoch January, 1843, of the declination, the dip, and the horizontal, vertical, and total force. A comprehensive index of all the parts is added to Appendix No. 18.

With these papers is presented one containing results of magnetic observations in the United States by the late Professor J. N. Nicollet, between 1832 and 1836, made out from the manuscript record by Assistant Charles A. Schott, under my immediate direction, and at my own expense. These results, though partly incomplete and not of an accuracy attainable by methods and instruments now in use, may, it is thought, be of use in investigating the secular change. The paper is given in Appendix No. 19. The observations had never been published, and the value of the results are enhanced because of the comparatively early period of the observations and the occupation of some localities not visited by other magnetists. It contains the magnetic horizontal force at nine stations, in Maryland, Missouri, Tennessee, Georgia, South Carolina, Mississippi, Alabama, and Minnesota; and the inclination at sixteen stations in the States just mentioned, and including also Kentucky, North Carolina, Louisiana, and Florida; also the declination at one station in Virginia. Some of the results were compared with such later ones as could be found in records by other observers.

AIDS TO NAVIGATION.

The results of a special examination made at the request of the Light-house Board, with reference to aids needed for navigation in Passamaquoddy bay and Penobscot bay, are given in Appendix No. 23. In the list which follows it (Appendix No. 24) a statement is given of the buoys set or replaced by parties while working on various parts of the coast. Acting Assistant Cordell has served during the entire season as inspector for the fifth district, and in the adjoining southern district close attention has been given to the light-house service by Assistant Boutelle.

TEN YEARS' INDEX.

The consolidated alphabetical index given with this report was prepared by Sub-Assistant F. F. Nes. It comprises references to the material of all the annual reports of the survey since the year 1853.

PART II.

In this part of the report notices will be made of each survey, including the dates, names of assistants, and statistics of the field-work. As far as practicable the triangulation will be described in the usual order, from north to south on the Atlantic coast, and from the southern boundary northward, on the Pacific coast The topography and hydrography will in general follow in the same order.

SECTION I.

FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COAST OF THE STATES OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND.—(SKETCH A, NOS. 1 AND 2.)

The annual progress in this section has not been at any time lessened by the war, advantage being taken of the season of the year for the assignment of parties, as, when their services were least called for in the southern sections, or when, by the advance in military operations their services were not immediately needed. A comparison with the progress made in former years will show favorably for the work done this season.

A condensed abstract of all the operations and parties is given in Appendix No. 1. In the descriptions which here follow, the same classification will be observed generally.

Triangulation of Union River bay, Maine.—This work connects with the triangulation of Blue Hill bay, as will be seen by reference to Sketch No. 2. Assistant G. A. Fairfield, with a party in the schooner James Hall, resumed duty in this section on the 15th of August. After visiting the connecting stations on the shores of Blue Hill bay, a reconnaissance was made and signals were erected for extending the triangulation eastward to Mount Desert island, and northward to Ellsworth. The southern limit of the work is Bass harbor. The angles were measured with the ten-inch theodolite, No. 91.

Mr. Horace Anderson aided in the field-work. The note-books of the triangulation, and the usual computations have been received in duplicate at the office. A summary of the statistics is appended:

Signals erected	11
Stations occupied	14
Angles measured	116
Number of observations	1,986

Triangulation of Penobscot river, Maine.—From the vicinity of North Bucksport the triangulation of Penobscot river has been extended northward, to Bangor, by the party of Assistant S. C. McCorkle. The additional work done is shown on Sketch No. 2. For final connexion with the primary triangulation, one or two stations yet remain to be occupied on the west side of the Penobscot. Assistant McCorkle resumed field-work on the 15th of August with the schooner Torrey, and closed for the season on the 27th of October. The following is a summary of the statistics:

Stations occupied	17
Angles measured	200
Number of observations	3,192

Twenty-two signals were erected by the party in the course of the season, half the number being tripods. The angles were measured with the six-inch Gambey theodolite, No. 29.

Shore-line survey of Letite Passage, (Passamaquoddy bay, Maine.)—The plane-table survey of Passamaquoddy bay was resumed by Sub-Assistant W. H. Dennis on the 1st of August. In continuation of his previous work he traced the eastern and the north shore of Deer island, and surveyed all the islands and ledges between it and White Horse island. The plane-table sheet of the season now contains thirty miles of shore-line. Field-work was continued until the 20th of October.

Mr. S. P. Holt served as aid in this party. The schooner Caswell was used for transportation.

Sub-Assistant Dennis passed the first part of the working season in Sections V and VI.

A preliminary chart of Eastport harbor and its approaches accompanies this report as Sketch No. 3.

Survey of Manhegan and other islands off Penobscot entrance, Maine.—A shore-line survey of all the islands in the southwestern approach to Penobscot bay has been made by Sub-Assistant F. W. Dorr, aided by Mr. F. Granger. The work is contained in three sheets, the first showing Manhegan and a number of islands immediately north of it. The second includes the Green islands, and ledges known as the northern and southern triangles. The third sheet embraces Matinicus, Ragged island, and Wooden Ball island.

The party of Mr. Dorr used the schooner Hassler for this work, between the 12th of August and the 20th of October. An aggregate of eighty miles of shore-line is represented on the plane-table sheets.

The previous occupation of Sub-Assistant Door will be stated under the head of Section VIII. His plane-table work of the preceding year is shown on the chart of Rockport and Camden harbors. (Sketch No. 4.)

Topography of St. George's river, Maine.—This work has been completed by the party of Sub-Assistant Charles Ferguson. Taking up the detailed topography at the Narrows, the survey was continued downward, and now embraces both banks of the river and the numerous islands that lie in the entrance. Maple Juice cove, Turkey cove, and Deep cove are among the indentations represented on the plane-table sheet. Its eastern limit joins with a survey made by the same party in 1862. The work of this year was commenced on the 20th of July and closed on the 25th of October. The following is a summary of the statistics:

Shore-line surveyed	29 miles.
Roads	14 "
Area of topography, (square miles)	9

The schooner Bowditch was used by this party for transportation. Sub-Assistant Ferguson had been previously engaged in field-work, which will be referred to under the head of Section III.

Topography of Booth bay, Maine.—The plane-table survey of this vicinity was commenced in August by Assistant P. C. F. West. Five small harbors of more or less importance are included on the topographical sheet. The principal of these, Booth Bay harbor, besides having considerable trade, is regarded by seamen as the best "harbor of refuge" on the coast of Maine. Assistant West states that it is accessible at all times and affords protection in all winds. The survey (Sketch No. 6) extends to and includes the eastern side of the lower part of Sheepscot river, and the coast from Cape Newaggen to Spruce Point, together with the islands in the vicinity. The field-work was continued until the latter part of November, with the following result in statistics:

Shore-line surveyed	45 miles.
Roads	10½ "
Area of topography, (square miles)	18

During the preceding winter and spring, Assistant West was on duty, first, with the army at and beyond Chattanooga, and afterwards in the vicinity of Richmond and Petersburg. His services there will be mentioned under the heads of Section III and Section VIII.

Topography of Sheepscot river, Maine.—The detailed survey of the eastern side of the Sheepscot river, including part of Westport, has been completed by a party in charge of Mr. R. E. McMath. Barter's island, Back river, Oven's Mouth river, and numerous islands in the lower part of the Sheepscot, are represented on the plane-table sheet.

This work was resumed on the 13th of August, and was completed on the 1st of November. The following is a summary of the statistics:

Shore-line traced	56½ miles.
Roads	13 "
Area of topography, (square miles)	8¾

In addition to the topographical work below Wiscasset, Mr. McMath developed the position of a rock with only four feet on it at low water. This lies four hundred metres north of Clou's ledge, in the Sheepscot river. He also determined the position of a ledge in Wiscasset bay, known as "Birch Point ledge," the bearings for which were communicated to the office. When examined, there was only eleven feet on the ledge.

Mr. McMath had been previously employed in Sections III and VI.

Topography of Arrowsic island, near Bath, Maine.—The detailed survey of the shores of the water passages between the Sheepscot and Kennebec rivers has been continued by the party of Assistant I. Hull Adams. That of the present season embraces the shores of Back river, above the Arrowsic bridge, and Hurl Gate, with the adjacent shores of Brookin's bay and Hall's bay. About four miles of shore-line were traced additional to the work previously done. The plane-table sheet shows five and a half miles of road, and the features of ground within an aggregate area of five and a quarter square miles. Field-work was commenced early in August and continued until the end of October.

Topography between the Kennebec and Androscoggin rivers, Maine.—The unfinished work on the neck or peninsula at the junction of the Androscoggin and Kennebec rivers was resumed on the 12th of August by Assistant R. M. Bache. About four miles of shore-line were run additional to the previous work, and details were filled in to extend the topography towards Brunswick, along the south shore of the Androscoggin. The additional work done by the party is embraced on the published chart of the Kennebec and Sheepscot rivers.

Supplementary topography in Casco bay.—The work of filling in with details the plane-table sheet of Great Jebeig, Cousins, Littlejohn's and other islands, and part of the Cumberland shore of Casco bay was taken up in the latter part of June by Assistant A. W. Longfellow. The shore-line had been previously traced. The contouring of the interior occupied the party until the 22d of September, the aggregate of lines run in that duty being eighty-five miles. Mr. Longfellow then traced the shore-line of the Gurnet, lying between Orr's island and Sebaskahegan or Great island. Eight miles of shore were traced in this part of the bay. The high wooded shores made it necessary to work with the plane-table by intersections. This service was continued until the 4th of November.

At the outset of the season Mr. Longfellow attended to the refitting and delivery to other assistants of the vessels left during the winter in his charge at Portland. His own party used the schooner Meredith for the duty in Casco bay.

Topography of Narraganset bay.—The shore-line survey being complete, Assistant A. M. Harrison commenced the detailed plane-table survey on the 8th of August, in the vicinity of Bristol, and continued work in the field until the 15th of November. The sheet turned in includes the shores of Warren, Barrington, and Kickemuit rivers, Bristol harbor, the entire eastern shore of Mount Hope bay, and part of the main shore of Narraganset bay, as well as the towns of Bristol and Warren, and the peninsula known as Bristol Neck.

Sub-Assistant C. Hosmer was attached to the party of Mr. Harrison, and worked with a second plane-table. He was employed in the first half of the working season in Sections VIII and IX.

The following are statistics of the topographical work of the season in Narraganset bay:

Creeks and ponds	17½	miles.
Roads	94¼	"
Marsh line traced	16	"
Area surveyed (square miles)	15½	

Some of the previous work of this party is shown on the charts of Bristol bay and Newport harbor, given with this report as Sketches Nos. 11 and 12.

Hydrography of St. George's river, Maine.—This work was completed by the party of Sub-Assistant F. P. Webber, between the 19th of August and the 4th of November. The hydrography is embraced in two sheets, one showing the soundings between the entrance of the river and the narrows; the other the soundings above and extending as far as Thomaston. A temporary tidal station was used for each sheet.

Near the mouth of Herring Gut harbor, (Sketch No. 2,) Mr. Webber connected his work with some of the lines of soundings run by the party of Mr. Cordell in 1863.

The shore-line for the hydrographic sheets was furnished by Sub-Assistants Ferguson and Dorr.

Mr. Cleveland Abbé was attached to the party as aid during the season, and Messrs. C. P. Dillaway, Franklin Platt, jr., and M. M. Defrees during part of it.

The schooner Bailey used by the party for transportation was returned to Portland at the close of the season.

A summary of the statistics of work is appended:

Signals erected	24
Points determined	31
Theodolite and sextant observations	206
Angles measured	3, 477
Miles run in sounding	228
Number of soundings	15, 668

In the former part of the working season Mr. Webber had been employed in Section V.

Hydrography of Quohog bay, Maine.—The party of Acting Assistant Alexander Strausz commenced this work on the 8th of August, using the schooner G. M. Bache for transportation. A tide-gauge was set up in Lowell's cove, and from thence southward to the lower end of Bailey's island, and eastward to Small

Point peninsula, (Sketch No. 2,) the soundings were prosecuted until the 17th of October. In the northern part of the bay some boat soundings yet remain to be made after the completion of the shore-line survey.

Quohog bay being one of the most rocky of the harbors of refuge on the coast of Maine, Mr. Strausz ran special lines of soundings in all the localities known at present as being dangerous. His chart marks twenty-one such localities, the principal of which are *Charity Ledge*, with fifteen feet, about half a mile from Jaquish island, bearing east; *Sister Grounds*, with seven and a half feet, about a mile north by east of White Bull island, a little to the westward of the channel leading into Cundie's harbor, and two other rocks without name, with five feet water on them lying, respectively, off Pond and Ram islands.

Mr. Strausz was aided in the hydrography by Messrs. L. A Sengteller and C. S. Hein. Other duty performed by the party will be mentioned under the head of Sections II and IV.

The following are satistics of the work done in this section:

Miles run in sounding	341
Angles measured	3, 145
Number of soundings	14, 238
Area of hydrography, (square miles)	34

Hydrography off Portland entrance, Maine.—Within the present season soundings have been extended southward and eastward about fifteen nautical miles beyond the previous limit of the hydrography at the entrance of Casco bay.

Lieutenant Commander T. S. Phelps, United States navy, Assistant Coast Survey, took up the off-shore hydrography on the first of September, with a party in the steamer Corwin, and completed soundings within about fifty square miles. Some of the lines run with the steamer extend broad off, and include about sixty additional square miles, but are yet to be crossed by other lines of soundings.

The following are the statistics of the work:

Miles run in soundings	321
Angles measured	534
Number of soundings	1, 590

The steamer Corwin returned to New York early in November.

Referring to the character of the hydrography, Lieutenant Commander Phelps observes that "sufficient has been accomplished to show that vessels uncertain of their position, in thick weather, should, in approaching Portland entrance, keep in forty fathoms or more, with soft bottom."

White Head Ground, off Cape Elizabeth, coming within the limits of the work of this year, was partially developed by the soundings.

Mr. Charles Junken served as hydrographic draughtsman in the party.

Physical survey of Boston harbor.—The physical survey of Boston harbor has been continued under my direction by Assistant Henry Mitchell, who has been occasionally detailed for that work at the request of the United States commission, consisting, at the opening of the year, of the late Major General Joseph G. Totten, Professor A. D. Bache, and Rear-Admiral C. H. Davis.

This is not the place to enter upon the details of this special survey, the results of which are annually published by the city of Boston. It may suffice to say that the lessening depth in some parts of that noble harbor has long been a source of anxiety among commercial men, and a thorough examination into the causes of the shoaling has been urged.

During the past season comparatively little field-work has been done in extending the survey, but the computations and tabular statements have been advanced, and a large amount of material prepared for publication.

From the commencement of the physical survey we have been encouraged by success, which has been fully appreciated by the intelligent community interested in the results. The Coast Survey, as I have before had occasion to remark, gathers many advantages from such undertakings in the collection of useful data for wider application.

The expenses of the special survey are borne by the city of Boston.

In the "Seventh Report of the United States Commission on Boston Harbor," the following remark occurs in reference to the labors of Assistant Mitchell:

"We must say in the beginning of this division, that we have thought it indispensable to place the whole of Mr. Mitchell's report, with its tables and illustrations, in the Appendix. It will be studied by the engineers and surveyors who follow the course of our investigations, and who, without this study, would be unable to satisfy themselves of the correctness of our conclusions. It will, moreover, be studied as a model of investigation in this branch of engineering in tidal harbors."

In the course of the year, Messrs. C. P. Dillaway, A. M. Wetherill, and J. W. Brown have served efficiently in the party of Assistant Mitchell as aids.

A preliminary chart of Boston bay and its approaches accompanies this report as Sketch No. 9.

Hydrographic examination in New Bedford harbor, Massachusetts.—At the close of the last surveying year the party of Assistant Mitchell was still on duty afloat, with the schooner Dana. After closing work at Sippican, as before reported, Mr. Mitchell determined the position of a rock in New Bedford harbor. In reporting the results of his observations, he refers to other features in the hydrography of this harbor, which may become the subject of further examination.

A chart of Sippican harbor is appended, (Sketch No. 10.)

Aids to navigation.—To obtain information needed by the Light-house Board, Assistant Mitchell was directed in August to visit Eastport harbor, Muscle Ridge channel, and Herring Gut harbor, on the coast of Maine, and to examine certain rocks reported by pilots and others as being dangers in navigation. The results of his examination, and his recommendation for buoys to mark the dangers, are given in the Appendix, (No. 23.)

Tidal and magnetic observations.—The continuous series of tidal records and monthly magnetic observations were kept up at Eastport by Assistant Edward Goodfellow until the first of April, and by Sub-Assistant A. T. Mostman until July, when the work at that station was closed, and a similar series of observations of both kinds commenced at Portland, under the care of Mr. H. W. Richardson. The record of the tides, by means of the self-registering tide-gauge, is designed here, as in the other important harbors where it is kept up, to furnish the data for predictions of the tides, besides connecting the temporary tidal observations at many stations along the coast, which are made by the hydrographic parties. The magnetic observations similarly serve to discover the secular changes in the variation, and to refer to a common period the determinations made at various times in other localities.

SECTION II.

FROM POINT JUDITH TO CAPE HENLOPEN, INCLUDING THE COAST OF THE STATES OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND PART OF DELAWARE.—(SKETCH No. 1.)

The work done in this section will be described in the usual order. An abstract showing the number of parties and the operations in which each was engaged will be found in Appendix No. 1. The several descriptions of work will be noticed as heretofore under separate heads.

Primary triangulation.—In a former report it was stated that in extending the primary triangulation for connecting the Epping base, in Maine, with the Fire Island base, (see Sketch No. 1, accompanying this report,) much difficulty had been encountered in obtaining satisfactory observations upon several of the lines across the States of Massachusetts and Connecticut, some of the lines being more than sixty miles in length. The difficulty alluded to was occasioned by unusual lateral refraction.

The line from Bald Hill to Station Ivy, both in Connecticut, is rather more than fifty-three miles long. It passes at about one-third of its length near the summit of a wooded hill, in crossing the township of Canton, Connecticut, and was frequently affected in a most remarkable manner by lateral refraction. The station Bald Hill was occupied by my party in September, 1861. Nearly all the measurements of angles centering there having been made when the temperature of the air ranged from fifty to eighty degrees Fahrenheit, it was deemed expedient to make additional observations at a season of the year when the temperature should range between forty and sixty degrees. My party was accordingly organized at Washington early in May, and placed in charge of Assistant G. W. Dean, who proceeded to Station Bald Hill, and completed in a satisfactory manner a second series of measurements of such primary angles as were deemed necessary.

After completing these observations the party was transferred to Station Wooster Mountain, in the township of Ridgefield, Fairfield county, Connecticut.

The requisite arrangements for the erection of signals and posting the heliotropers were made by Assistant Dean and Sub-Assistant R. E. Halter, while the usual preparations for occupying the stations were made as in former years by Mr. Thomas McDonnell.

The instruments at Station Wooster were in position, and every preparation had been made for commencing the geodetic operations on the 1st of July, but unfavorable weather prevented until the 14th, when the measurements of angles with the thirty-inch theodolite were begun, and were continued for two days. During the following six weeks the atmosphere was remarkably dry and hazy, and for many consecutive days the smoke arising from the accidental burning of large tracts of forest timber in this and the adjoining States of Massachusetts and New York, rendered it quite impossible to observe upon objects at a greater distance than four or five miles from the point occupied by the observer.

In many respects the weather throughout New England during the season just closed has been very similar to that of the summer of 1854, which, no doubt, is still well remembered by most of the present residents of this section of country, and more especially by those in the State of Maine, many of whom suffered great losses from the destruction of thousands of acres of timber, numerous dwelling-houses, and other valuable property.

Station Bald Hill.—The measurements of angles at this station were commenced on the 22d of May, and completed on the 7th of June. The number of observations made with the thirty-inch theodolite by Assistant Dean was two hundred and sixty-four.

At Station Wooster Mountain the measurements of angles were commenced on the 14th of July, and completed on the 10th of October. The number of signals observed upon was thirteen, five of which were primary and eight secondary, and for this purpose sixteen hundred and sixty observations were made.

The elevations of ten stations above the sea level were determined by the measurement of vertical angles with the eight-inch Gambey theodolite, C. S. No. 57, in which fourteen hundred and sixteen observations were made.

The most distant signal observed upon during the season was at Station Ivy, and visible from Bald Hill about fifty-three and a half miles in a direct line. Three other signals were between thirty-seven and forty-two miles distant from station Wooster. The relative positions of the several stations are shown in Sketch No. 1.

The area within the limits of the triangulation completed during the season, estimated in the usual manner, is seven hundred and twenty square miles.

Magnetic observations.—The geological formation of Wooster mountain appears to be chiefly gneiss rock, which, in the immediate vicinity of its summit ridge, has been uplifted into numerous cliffs varying from twenty-five to fifty feet in height. The strata of the rock at the several out-croppings inclines at various angles, and in many different directions, and although no trap rock was found in the immediate vicinity of the geodetic station, the results obtained in determining the magnetic dip at different points near the summit of the mountain indicate the presence of trap dikes in that vicinity.

After making experimental observations at several points the magnetic station was finally located about eighty metres southwesterly from the geodetic station.

The magnetic observations consisted of one hundred and forty-six readings of the suspended magnet on three days for ascertaining the declination; and the horizontal intensity and moment of inertia were determined from two complete sets of experiments on two days. The magnetic dip was ascertained at three points from nine complete sets of observations with two needles. These observations were made by Sub-Assistant R. E. Halter, aided by Mr. F. W. Perkins, who served in my party as geodetic recorder during the season.

Meteorological observations.—The usual meteorological journals were kept by Mr. Perkins, in which were recorded two hundred and eighty-nine readings of the mercurial and aneroid barometers, and of the wet-bulb and dry-bulb thermometers, in connexion with the direction and force of the wind and character of the clouds.

All the original records were duplicated, and the requisite abstracts of angles and reductions were completed in the field.

Twenty volumes of original and duplicate records were deposited in the archives at the close of the season.

It is due to Assistant Dean to say, that, in conducting the details of operations by my party during the season just closed, his services, as in former years, have been rendered with fidelity and success.

Triangulation east of Hudson river, New York.—The triangulation connecting that of the Hudson with the primary work passing through New England was resumed on the 1st of September by Assistant Edmund Blunt, and was pushed until the 1st of November. Sub-Assistants J. S. Sullivan and A. T. Mosman were attached to the party, the latter joining on the 27th of September, after completing duty in Section I.

The following is a summary of statistics:

Stations occupied	11
Angles measured	196
Number of observations	7,038

Sub-Assistant Sullivan is now about to take up field duty in Section III, and Sub-Assistant Mosman in Section VIII.

Triangulation of Barnegat bay, New Jersey.—The triangulation of the coast of New Jersey was resumed by Assistant John Farley, at Manasquan inlet, in the middle of August. Having made the needful reconnaissance before the close of the preceding season, the work was continued southward through Barnegat bay to a point about sixteen miles below Manasquan. Eleven stations were occupied, and thirteen points determined by eleven hundred and thirty-four angular measurements. The party of Mr. Farley continued in the field until the end of November.

Topography of Hudson river, New York.—The detailed plane-table survey of the shores of the Hudson was resumed at the previous limit above Sing Sing, and on the eastern side has been extended to Croton village. The party of Assistant H. L. Whiting took the field for this duty on the 27th of August, and was aided by Mr. H. G. Ogden. Sellers' Point and the shores of Croton river were surveyed as far up as the crossing of the Albany turnpike.

On the 6th of October the topography of the west side of the Hudson was taken up at Nyack, and continued upwards to include the village of Haverstraw. A breadth of about half a mile was given to the detailed survey. On this sheet the shore-line of Rockland lake was traced, and some remarkable features of topography, in reference to which Mr. Whiting observes: "The circular crest of hills from the 'Verdiretige Hook' to 'High Tor' (seven hundred and thirty and eight hundred and twenty feet respectively) rises abruptly from the river shore at an angle impossible to ascend, with perpendicular cliffs at the summit crest. This narrow ridge of the entire line of summits, with the steep slope of descent westward, of from four hundred to six hundred feet, to the undulating fields at the base, forms one of the most striking natural features in the whole of the river topography. As a subject for contour, it is the most remarkable that has come within my experience in Coast Survey work." Sub-Assistant Cleveland Rockwell joined the party on the 8th of October. His energy in meeting the difficulties peculiar to the work of the season are warmly commended in the report of Assistant Whiting.

The following are statistics of the topography:

Shore-line traced	$21\frac{1}{4}$	miles.
Roads	37	"
Creeks	6	"
Marsh line	$3\frac{1}{2}$	"
Area surveyed (square miles)	9	

Field-work was continued by this party until the end of November. Mr. Rockwell had previously been on duty in Section III and Section VIII, and Mr. Ogden in Section IV.

Topography of Navesink Highlands, New Jersey.—The supplementary plane-table work needed in the vicinity of Navesink was taken up by Assistant C. M. Bache on the 11th of September, with a party, in the schooner Dana. Good progress was made in the survey until the 22d of the month, but the difficulty then existing in regard to the fluctuating increase of wages made it impracticable to retain the hands at the limit allowed by the regulations. A new crew was, therefore, employed for the special purpose of taking the vessel back to Peekskill, where she was laid up for the winter.

Sub-Assistant T. C. Bowie was attached to this topographical party. Assistant Bache had been previously employed in Section III, and Mr. Bowie in Section VIII.

Topography of Absecom inlet, New Jersey.—The plane-table survey of Absecom inlet was commenced on the 1st of November, 1863, by Mr. H. W. Bache. Work was closed on the 15th of January, by reason of the severity of the weather, and was again resumed on the 1st of July. The survey (Sketch No. 16) includes Atlantic City and Brigantine beach on the opposite side of the inlet, and the water thoroughfares inland for about two miles. Very considerable changes were noticed on comparing the shore-line with that traced in 1844.

Mr. H. G. Ogden aided in the field-work. The survey was completed on the 19th of August.

Trial Course buoys.—At the request of the Chief of the Bureau of Navigation, Admiral C. H. Davis, two buoys were set in Raritan bay, between Sandy Hook, East Beacon, and Prince's Bay light, to mark the trial course for vessels of the navy.

This service was performed by Mr. Alex. Strausz in June. The buoys were placed two nautical miles asunder, and show about twenty feet out of water. The depth at the east buoy is twenty-six feet, and at the west buoy twenty-seven feet at mean low tide.

The previous occupation of Mr. Strausz will be mentioned under the head of Section IV.

Sandy Hook.—In March last a special commission, appointed by the War Department, visited Sandy

Hook, examined the changes which had taken place in the shore-line, and made comparison of the numerous surveys. The commissioners were accompanied by Assistant Henry Mitchell, who made the last hydrographic survey of the vicinity, and had gained special information in his former employment, under my direction, while the survey of New York bay was in progress.

The hydrographic changes in the neighborhood of Sandy Hook are very slight, but the extension of the extreme point of the land, and the wear on either shore, were more rapid in the year 1862 than at any previous time. In the year 1863 the extension continued, but the wear was not so great as in the previous year.

Hydrography of Absecom inlet, New Jersey.—The approaches, inlet, and harbor at Absecom, New Jersey, were sounded out in June last by the party of Lieutenant Commander T. S. Phelps, with the steamer Corwin.

The following are statistics of the work :

Miles run in sounding	92
Angles measured	645
Number of soundings	6, 426

A tidal station was occupied for the adjustment of soundings on the chart. The result of the survey is given with this report as Sketch No. 16.

Later in the season the party in the Corwin was employed at the Cape Lookout shoals, and also near Portland entrance.

Special examination on Delaware river.—At the request of the Navy Department Assistant Mitchell was sent in January last to observe the action of floating ice in the neighborhood proposed as navy yard sites in Delaware river. The severity of the season afforded an opportunity of noting the worst features of such action. Every fact which seemed to bear upon the question was collected with diligence, and reported to the department.

Mr. J. W. Brown and Mr. A. M. Wetherill aided in this service.

Tidal observations.—The permanent self-registering tide-gauge at Governor's island, New York harbor, has been kept in operation by Mr. R. T. Bassett, who has also continued to make observations on a box gauge for comparison at the dock of the Hamilton Avenue ferry, in Brooklyn.

SECTION III.

FROM CAPE HENLOPEN TO CAPE HENRY, INCLUDING THE COAST OF PART OF DELAWARE, THE COAST OF MARYLAND, AND PART OF THE COAST OF VIRGINIA.

All the field-work in this section has been done, as in the preceding years of the war, with immediate reference to military or naval operations, or in connexion with purposes of defence. A great amount of geographical data has thus been collected from localities intended to be embraced in the regular operations of the survey. The work done will be described under the usual heads. A synopsis showing the locality in which each of the parties has been employed will be found in Appendix No. 1.

Latitude and longitude of points in West Virginia.—To meet an application made at the approach of last winter by the chief engineer of the military department of West Virginia, the late Lieutenant J. R. Meigs, United States corps of engineers, the telegraphic method of determining longitude was applied by Assistant G. W. Dean, in connexion with the ordinary method of observing for the latitude at eleven stations in the department. Mr. Dean made his party arrangements at Clarksburg early in December, and then took charge of the operations requisite at Washington city, the purpose being to use the military telegraph lines, and to refer all the determinations to the station in that city. Sub-Assistant A. T. Mosman and Mr. S. H. Lyman were detailed with a sidereal chronometer and the eight-inch Gambey vertical circle No. 57 to observe at the western stations. Observations were begun on the 23d of December, and closed on the 24th of March.

In determining longitude, Assistant Dean used at Washington a mean time chronometer, of which the corrections and rate were obtained by comparison with the time of the Naval Observatory, by the kind permission of its superintendent, Captain Gillis, United States navy. On nights favorable for observing, if the line was at the same time available, the mean time chronometer was taken to the War Department, and signals were exchanged with the observer in West Virginia, the time of each being noted on the chronometers at both ends of the line. Mr. Dean was aided in these operations by Mr. P. H. Donegan. Seven signals thus made during a single minute at Washington were considered a series of comparisons. Signals were then made from the western station, and again from Washington, alternating until eight or ten series were successfully exchanged on the same night by the "eye and ear method." From subsequent comparison of the times noted by the two chronometers, the longitude was deduced of the stations at Martinsburg, Clarksburg, Cumberland, Grafton, Cameron, Wheeling, Parkersburg, Point Pleasant, South Point, (Ohio,) Gauley Bridge, and Charleston. The exchange of time signals by telegraph was hindered at several of the stations, and prevented entirely at Charleston by the movements of guerilla parties. Mr. Mosman determined the local time at the western stations by two hundred and eighty observations on twenty standard stars.

At all the stations already named the latitude was determined from one hundred and twenty-five observations on eleven stars. These determinations of geographical position, although not possessing the accuracy of those made in connexion with the geodetic operations of the Coast Survey, supply a far closer approximation to the true relative positions of the stations than was previously known, and greatly assisted in the adjustment of the old county maps and recent military surveys, so as to form an improved map of the department.

Lieutenant Meigs furnished transportation for the party and instruments. The operations were facilitated also by the obliging courtesy of Major Eckert, superintendent of the military telegraph lines at Washington.

The records of these observations have been received at the office in duplicate as usual, and the reductions for latitude and longitude have been completed, and applied in correcting the map of the military department.

Assistant Dean during the summer and autumn was on duty with my field party in Section II. On closing the work in Virginia, Sub-Assistant Mosman was assigned to duty in Section I.

Magnetic observations.—While he was engaged with the party in the determination of geographical positions in West Virginia, Mr. Lyman observed the approximate declination of the magnetic needle at the principal stations, using the declinometer D. 22. The instrument was generally adjusted in the open air, and the direction of the suspended magnet was noted at intervals of a few minutes during an hour or more.

From the unusual severity of the winter, and the exposure to which the party was necessarily subjected in passing from station to station, and in night observations, the health of Mr. Lyman became so seriously impaired as to induce his resignation.

Topography of the environs of Baltimore, Maryland.—The plane-table survey of the ground commanded by the defences erected last year in the vicinity of Baltimore was continued during the winter by two parties. Sub-Assistant C. T. Iardella succeeded Sub-Assistant Donn in November, and Assistant C. M. Bache was assigned early in January. Both parties have continued the detailed survey under the direction of Colonel W. F. Raynolds and other officers who successively filled the position of chief engineer of the middle department. Mr. Iardella executed the topography eastward of Jones's falls from the city to Cross Keys village, and thence in a circuit towards the Baltimore and Philadelphia railroad. The circuit westward of Jones's falls was surveyed by Assistant Bache as far as the Franklin turnpike, where he joined with the plane-table work done last year by Sub-Assistant Donn in the western approach to the city.

Sub-Assistant Iardella is still engaged in the field. During part of the season he was aided by Mr. H. W. Bache. The occupation of Mr. Donn in the present season will be stated elsewhere in this section, and under the head of Section VIII. Assistant Bache continued the survey near Baltimore until September, and was then assigned to duty in Section II. In the early part of the season he was aided by Mr. Charles S. Hein. The following are the statistics of the survey of the environs of Baltimore :

Roads surveyed	96¼ miles.
Streams surveyed	77¾ "
Area of topography, (square miles)	20½

Sub-Assistant Donn being incidentally in Baltimore during the rebel raid in the early part of July, promptly reported to the military authorities for such service, if needed, as he had rendered last year at the time of the invasion of Maryland by the rebel forces under General Lee.

Topography near Washington, D. C.—Sub-Assistant Charles Ferguson was employed between the 10th of December, 1863, and the 20th of March following, in extending the topographical survey along the north-east line of the District of Columbia. This work was done at the request of the engineer of defences. It adds a breadth of about three miles to the District map along that boundary. About half of the additional area had been previously mapped. The Upper Marlboro' and Long Old Fields roads appear on the sheet of Mr. Ferguson, and the creeks known as Cabin Branch and Beaver Dam branch of the Potomac, and the southwest branch of the Patuxent.

The statistics of the work are as follows :

Roads surveyed	32 miles.
Creeks surveyed	25 "
Area, (square miles)	15

Mr. Ferguson was employed during the summer in Section I.

Topography of Arlington Heights, Virginia.—By request of the Quartermaster General in June, a minute plane-table survey has been made of the Arlington estate, comprising two hundred and fifty acres, with reference to the use of the ground as a national cemetery. Contour lines were traced on the map corresponding to successive elevations of five feet. The lines run with the level for this purpose make an aggregate of twenty-eight miles, and determine the height of the ground at three thousand points.

This survey was made by Mr. E. Hergesheimer, assisted by Mr. R. E. McMath, with a working party detailed from the 169th regiment of Ohio militia. The map was drawn at the office on the desired scale by Mr. Hergesheimer, and photographed copies of it have been furnished to General Meigs. Mr. McMath had been previously on duty in Section VI. The remaining part of the summer and autumn was occupied in Section I.

Reconnaissance duty in the James river campaign, Virginia.—After leaving Section VIII, Assistant P. C. F. West rejoined the command of Major General W. F. Smith at Yorktown in March, and remained with the staff, in which service he ranked as captain, until the 14th of June. He accompanied General Heckman on a reconnaissance towards Port Walthall, which ended in a brisk engagement. Next day Captain West was sent with a small detachment, but falling in with the reserve of the rebel army returned to camp. During the battle at Swift creek he was on duty with the staff of General Martindale. Besides the duties of reconnaissance he was actively engaged in the battle at Kingsland's creek, and in all the actions prior to it, in the vicinity of Bermuda Hundred.

When Major General Smith moved his command to the head of York river, Captain West was sent with twenty men up the south bank of the Pamunky, and opened communications with the army of Lieutenant General Grant, then on its march southward. He took part in both of the battles at Cold Harbor, and remained on the staff of General Smith until the command was again transferred to the banks of the James river.

Assistant West has now served three years with the army, and being active in the front, he has participated in more than twenty battles. The approach of summer bringing the return of symptoms which had before prostrated him by severe illness, Mr. West returned north and passed the remainder of the season in topographical duty, which has been mentioned under the head of Section I. Major General Smith has borne ample testimony as to his gallantry in action, and in regard to his usefulness in the command in surveying and engineer duty.

Surveys at Bermuda Hundred, Virginia.—At the request of the chief engineer of the military department of Virginia and North Carolina, Sub-Assistant J. W. Donn was assigned to duty in April. He accompanied the army of Major General Butler in the movement on Bermuda Hundred, and made special surveys at Fort Powhatan, Wilson's Wharf, and Deep Bottom. Very important additions were made to our military map of southeastern Virginia from the material which he collected and forwarded to the office. Mr. Donn continued in service under the orders of Brigadier General Weitzel until the 10th of September. He was aided in topographical duty during July and August by Mr. H. L. Marindin.

Service with military forces in Virginia.—At the end of October, 1863, Sub-Assistant Cleveland Rockwell reported to Major General Foster at Fortress Monroe. This was just previous to the transfer of that officer to Knoxville, Tennessee. Major General Butler, on taking command at Fortress Monroe, requested the services of Mr. Rockwell for the survey of a depot for prisoners at Sewall's Point, and that duty was completed without delay. Mr. Rockwell then started for the west, and leaving Cincinnati at the close of November, reported as soon as possible at Knoxville. His service in that vicinity will be referred to under the head of Section VIII.

Under orders from Major General Franklin, Assistant J. G. Oltmanns joined the army in the Shenandoah valley on the 16th of September last, and reported for topographical service to Brevet Major General Emory. In the battle of the 19th, at Winchester, he served on the staff, and in the same capacity in the battle at Fisher's Hill on the 23d. The last-named position he mapped for the use of the commanding general.

Mr. Oltmanns accompanied the army in the rapid movement up the Shenandoah valley to Mount Crawford, and assisted in repairing bridges to further the advance. On the return he performed reconnaissance duty, and after the memorable battles at Cedar Creek and Middletown, in both of which he was actively engaged, made a detailed sketch of the country from Middletown to Strasburg, to show the movements of the 19th army corps and the approaches to the rebel positions. He is now at work on a survey of the encamped ground of the army on Opequan creek.

The field service of Assistant Oltmanns preceding the duty here alluded to will be mentioned under the head of Section VIII.

Military map of West Virginia.—At the request of the chief engineer of the military department of West Virginia, the late Lieutenant Meigs, I detailed Mr. A. Lindenkohl from the office early in October, 1863, to assist in compiling the data which had been collected at Clarksburg, from the army surveys and by expeditions of the cavalry forces. Other material procured from the records of surveys at Annapolis and Baltimore, and from the Engineer Bureau, was made auxiliary to the preparation of a military map of the department. Mr. Lindenhkohl assisted also in the construction of a large map of the environs of Cumberland, and computed the latitude of a number of places in the State from sextant observations by Lieutenant Meigs. He was employed in West Virginia until the 16th of February, and then returned to duty in the Drawing Division of the office.

Hydrographic survey of Trent's Reach (James river, Virginia.)—This was the first service rendered by Sub-Assistant J. S. Bradford after joining the staff of Admiral Lee, in June. The soundings, about two thousand in number, were completed on the 14th of the month, and embraced the bar and the entire expansion of the river on the south side of Farrar island. The battery at Howlett's being evacuated by the enemy on the morning of the 14th, Mr. Bradford took advantage of their absence and sounded the upper part of the reach as far as the upper wharf, from which he had been several times fired upon previously. This service proved to be timely, as the rebel forces reoccupied the battery in the evening, a few hours after Mr. Bradford had examined the ground, with the intention of making a close survey of the site. Soon after, the use of obstructions in Trent's reach having been decided upon, Mr. Bradford was called on to determine the line which they were to occupy. When the work thus marked out was completed the entire line was designated on his chart, and copies of the sheet were furnished for the use of the squadron. The party was repeatedly fired on from the battery at Howlett's while engaged in locating the line.

Sub-Assistant Bradford remained on duty with the flag-ship in James river until the third of July. The remainder of the month, excepting a few days, was passed at Hampton Roads in preparing charts for the use of the blockading fleet off Wilmington, and for the Navy Department. During this time Mr. Bradford visited Trent's reach twice under the orders of the admiral, on duty connected with the line of obstructions. His subsequent service with the North Atlantic blockading squadron will be stated under the head of Section IV.

Tidal observations.—The tidal observations at Old Point Comfort, Virginia, were continued in charge of Mr. M. C. King until March 1st, when he resigned. The station was then intrusted to Ordnance Sergeant C. Kelly., United States army, who has continued the observations to this time successfully.

SECTION IV.

FROM CAPE HENRY TO CAPE FEAR, INCLUDING THE COAST OF PART OF VIRGINIA AND OF PART OF NORTH CAROLINA.

The operations to be described under this head were carried on by parties assigned to work under the orders of Admiral S. P. Lee when in command of the North Atlantic blockading squadron. One of the parties remained during the entire year on duty with the squadron, and is now engaged under the orders of Admiral Porter. An abstract of the parties and operations is given in Appendix No. 1. It will be seen that the results obtained fall in with the regular working of the survey.

Survey of Roanoke river, North Carolina.—This survey, as well as others to be noticed presently, was made at the special request of the flag officer of the North Atlantic blockading squadron, Admiral S. P. Lee. It includes the river and its shores to Ryan's Thoroughfare, above Plymouth, North Carolina, and below to its mouth in Albemarle sound.

Sub-Assistant R. E. Halter reported on the flag-ship at Hampton Roads on the 12th of November, 1863. Under directions then received he applied to the senior naval officer at Newbern, and was assigned to quarters on the gunboat Seymour. On the 23d a base line was measured above Plymouth, and triangulation made in connexion with it. The work was then pushed on, subject only to interruptions caused by frequent attacks from small parties of the rebel forces. Mr. Halter completed the triangulation and the topography by the end of January.

The Roanoke river below Ryan's Thoroughfare was sounded by Sub-Assistant J. S. Bradford and his aids, Messrs. H. M. De Wees and H. L. Marindin. Batchelor's bay was included, and the water passages known as Middle and Eastmost rivers. This work was done with a boat from the steamer Seymour, and under many disadvantages, the vessel being often needed for picket duty and for delivering despatches. Mr. Bradford completed soundings in this vicinity on the 10th of February. The statistics are thus stated in his report:

Miles run in sounding	195
Angles measured	839
Number of soundings	13,451

Topography of Roanoke island, North Carolina.—The survey of Roanoke island was in progress in the spring of 1861, and would have been completed before the ensuing summer, but the instruments there in use were seized and kept by persons acting under the State authorities of North Carolina, as mentioned in my report of that year.

While engaged in the vicinity this season Sub-Assistant Halter found means to complete the topography of the south end of the island. The work is in detail, and, like all the field-work of the present season in this section, is conformable in character to the regular operations of the survey of the coast.

Survey of Croatan sound, North Carolina.—Sub-Assistant Halter took up this work on the 20th of February, but its progress was much hindered by bad weather. Field-work, including the triangulation and shore-line survey, was finally closed on the 26th of May. In the interval, the steamer Seymour was frequently on naval duty, and part of the time was employed to watch the rebel movements in Roanoke river. On such occasions Sub-Assistant Halter continued on service with the vessel. While in the vicinity Mr. Halter took the opportunity to visit the site of the primary base line on Bodie's island. The marks at the ends of the line were found readily, as were also several of the adjacent stations used in the main triangulation of the coast of North Carolina. The following summary comprises the statistics of field-work on Roanoke river and Croatan sound:

Signals erected	73
Stations occupied	48
Angles measured	176
Number of observations	373
Shore-line surveyed, (miles)	51

During the summer and autumn Sub-Assistant Halter was on duty with the party of the superintendent in Section II.

Admiral Lee has expressed in written communications a high sense of the value of the services rendered by the parties attached to his squadron. By direction of the flag-officer the obstructions placed by the enemy in Croatan sound at the outset of the war were examined in February by Sub-Assistant Bradford. At several intervals, permitted by the exigencies of the naval service in the succeeding months closing with May, the hydrography of the sound was developed and its channel marked by buoys from Roanoke marshes to Croatan light, the soundings being extended as far up as Pork Point. This was a work of much necessity, vessels of the squadron having frequently grounded in going through the sound. Both lines of obstructions put down by the enemy have been carefully marked on the chart. The statistics of the work are as follows:

Miles run in sounding	208
Angles	1,486
Number of soundings	23,664

The difficulties that multiplied in the way by the frequent withdrawal of the steamer for naval service were in part relieved by the interest taken in the work by Mr. Newton Eggleston, acting second assistant engineer of the Seymour, and by Mr. George Doten, purser's steward. Both served as recorders in the hydrographic party whenever their regular duties would permit.

After leaving this section, Sub-Assistant Bradford continued on active duty in Section III on the flag-ship of Admiral Lee, but returned in September with a vessel specially assigned for use in prosecuting hydrography. His subsequent work will be mentioned presently. The vessels detailed to attack the rebel ram Albemarle were piloted through Croatan sound by the hydrographic party in the Seymour.

Triangulation of Neuse river, North Carolina.—A party organized under the charge of Assistant G. A. Fairfield for continuing the preliminary survey of the Neuse river was at New Bern on the 4th of December last, fully prepared for resuming work. At that time a large band of guerillas was making incursions along the lower part of the river, rendering it unsafe to use the schooner James Hall, which was to serve for transportation. The convoy of a gunboat was promptly tendered by the senior naval officer, Commander Davenport, but the early opening of the military campaign by the rebel forces in the vicinity of New Bern made it frequently necessary to withdraw the protecting vessel for naval service. After repeated attempts the work was resumed on the 25th of February, when hostile movements in the waters of North Carolina called for full activity in the naval squadron and for vigilance in those having the care of transport and other vessels. Under these circumstances Assistant Fairfield worked several days at a new station in the triangulation of the Neuse river, and then assisted with his vessel in meeting a call made by Admiral Lee for a resurvey of Hatteras inlet. He was aided in this section by Mr. Horace Anderson. The party and vessel were employed during the summer in Section I.

Hydrography of Neuse river, North Carolina.—This work was commenced on the 1st of January by the party of Acting Assistant Alexander Strausz, and arrangements were made at the same time for running the shore line of the river below New Bern. Good progress during the month had extended the soundings as far down as the lower blockade. New Bern was attacked by the enemy on the 1st of February. The work was at once discontinued. Mr. Strausz, with his aids, Messrs. H. G. Ogden and Gershom Bradford, tendered themselves for naval duty on board of the gunboat Commodore Hull, as aids to perform watch duty, and the offer was accepted. Mr. Strausz, knowing the channel, set three buoys for leading up or down the river, and piloted one of the army transports by the nearest route of communication between Fort Anderson and Fort Chase. At the request of General Peck he also made a reconnaissance of Batchelor's creek with armed boats detailed for that service by Commander Davenport. Defensive operations in the vicinity of New Bern occupied the party until the 1st of March.

Resurvey of Hatteras inlet, North Carolina.—This work was done at the request of Admiral Lee. No other vessel being then available, Mr. Strausz used the surveying schooner James Hall, belonging to the party of Assistant Fairfield. The month of March was occupied in running soundings to determine the hydrographic changes and in tracing the shore-lines of the inlet. Buoys were then set to mark the new channel—three in the swash and a first-class can-buoy in Pamplico sound. The swash buoys being carried away by heavy gales in April, were replaced after a careful re-examination of the channel.

Of the changes observed at Hatteras Mr. Strausz remarks: "The channel now used over the swash is entirely different from that shown on the chart of 1861. The new one has opened since December, 1863. The depth of water over the new swash at mean low tide is a little over seven feet—the mean rise and fall being one foot and two-tenths."

The following is a summary of statistics taken from the reports of Mr. Strausz:

Miles run in sounding	91
Angles	808
Number of soundings	6,040
Tidal stations occupied	3
Shore-line traced, (miles)	40

Mr. Strausz remained in service in the waters of North Carolina until the end of May, and was subsequently employed in Sections I and II. Mr. Ogden, of his party, has since been on duty in Section II, and Mr. Bradford in Section V.

Hatteras inlet was re-examined in the latter part of September by Acting Assistant Edward Cordell. The changes then observed required a removal of the buoys. The channel to the westward of the Middle Ground was found to be filled up, and the west breakers extended across it nearly to the buoy which marks the eastern extremity of the Middle Ground. The main channel had deepened to eighteen feet at low water, (spring tide,) with lines of continuous breakers on either side of it. The changes reported by Mr. Cordell were illustrated by a sketch of soundings. These appear in the new edition of the preliminary chart of Hatteras inlet which was issued from the office in October.

Resurvey of Beaufort Harbor entrance, North Carolina.—For this service Acting Assistant Edward Cordell reported to Admiral Lee at Fortress Monroe on the 25th of March, and was assigned to duty under the immediate orders of Captain Dove at Beaufort, North Carolina, on the 30th. A small vessel belonging to the blockading squadron being assigned for the use of the hydrographic party, Mr. Cordell at once commenced a resurvey of the bar and of the channel leading into the harbor. "The principal changes in the channel occur at black buoy No. 3. In 1862 it was placed in twenty feet of water to mark the point of the southwest breakers. Since then the breakers have extended westward about a hundred yards beyond the first position of the buoy, and but eight feet of water was found at its position. It was removed into sixteen feet water." Other changes of depth are stated in Mr. Cordell's report. (Appendix No. 6.)

Messrs. A. M. Wetherill, Jas. W. Brown, and Franklin Platt aided in this resurvey. The work was completed on the 2d of May, and a new edition of the chart furnished from the office, with revised sailing directions for the use of the blockading squadron.

The statistics of the resurvey at Beaufort entrance are as follows:

Miles run in sounding	137
Angles observed	2,037
Number of soundings	11,959

The buoys were re-set so as to mark the line of best water as developed by the resurvey.

In the latter part of December the channel into Beaufort had been examined by Acting Assistant Alexander Strausz. A report on its course, direction, and depth of water was, at the same time, forwarded to the flag-officer, with tracings from the chart then made.

Hydrography of Core sound, North Carolina.—In connexion with the work mentioned under the last head, Mr. Cordell during the summer sounded out the channel which leads from Bogue sound through the straits into Core sound, and extended the inside hydrography as far as Harbor island, including also the waters of Beaufort harbor, North Carolina. This survey shows that the channel of Core sound gives only five feet at the shoal places. The channel was marked by the party with three iron can buoys and one hundred and thirty-five stakes. The particulars developed by the soundings are stated in the Appendix, (No. 7.)

Messrs. Wetherill and Platt served in the party as aids.

In addition to hydrographic service, Mr. Cordell, throughout the entire season, performed the duties of acting light-house inspector, and reported regularly to the chairman of the board.

The results of the work in Core sound, which was completed by the 9th of September, are shown on Sketch No. 24.

Hydrographic reconnaissance of the Cape Lookout shoals, North Carolina.—The Cape Lookout shoals were examined in August last by Lieutenant Commander T. S. Phelps, United States navy, Assistant Coast Survey. Sketch No. 25 shows the results of this reconnaissance. Three shoals, probably parts of the same ridge, were found, one extending S. by E. ¼ E. from the south point of the constant breaker, three miles to seaward, or ten and a half miles from the light-house. The bottom here is quite uneven, the depth on the shoal lumps varying from about nine feet to eighteen feet. About a mile and a half to the southward and eastward the soundings gave five and a half fathoms, and further still in the same direction, or SE. by S. ½ S., thirteen and a half miles from the light-house, five and a quarter fathoms were found. The examination developed no indication of shoal ground at present outside of the last-named limit.

The report made by Lieutenant Commander Phelps is given in the Appendix, (No. 5.)

The statistics are thus reported:

Angles determined	45
Miles run in sounding	166
Number of soundings	1,665

The steamer Corwin and party of Lieutenant Commander Phelps were subsequently employed in the vicinity of Portland entrance, as was stated under the head of Section I.

Hydrography of Bogue sound, North Carolina.—This work was commenced in August, under the orders of Admiral Lee, by Sub-Assistant Bradford, who had served on his staff during the summer. The steamer Nansemond, then awaiting the completion of a new boiler, was assigned for temporary service in the hydrography, but her draught made it impracticable to take that vessel higher up than Carolina city. Good progress was made, however, with the prospect of early completion, but not before the steamer was called to Baltimore to receive the boiler. By direction of the Admiral, Mr. Bradford went in the vessel to expedite the repairs of the steamer Seymour, which had been in general use for hydrographic purposes in this section. Mr. H. M. De Wees joined the party as aid at Hampton Roads, and accompanied Mr. Bradford to Beaufort, North Carolina, where he arrived on the 27th of September. The succeeding fortnight was employed in preparing charts for the use of the naval forces in the projected attack on Wilmington. In addition to the Coast Survey data these contain all the information gained by reconnaissance in reference to the number and strength of the enemy's works, and views of the coast, and of the defences taken from different points of observation. The new charts were delivered to Admiral Lee just previous to the transfer of the command of the North Atlantic squadron to Admiral Porter. At the request of the last-named officer Sub-Assistant Bradford joined his flag-ship, and is now on duty with the squadron. He reports the following statistics of the partial survey of Bogue sound, which work he expects to complete hereafter:

Angles measured	918
Number of soundings	10,049

SECTION V.

FROM CAPE FEAR TO ST. MARY'S RIVER, INCLUDING PART OF THE COAST OF NORTH CAROLINA AND THE COAST OF SOUTH CAROLINA AND GEORGIA.

The parties on the coast of South Carolina and Georgia, while prosecuting the regular work of the survey, when practicable, also rendered incidental service in piloting vessels of the South Atlantic blockading squadron. Besides the surveys made at the request of Admiral Dahlgren, the parties were kept in readiness for reconnaissances in co-operation with the forces of Major General Foster. A summary given in Appendix No. 1 shows the number of parties and the localities of work. In this chapter the operations will be, as usual, referred to under separate heads.

Resurvey of Charleston bar, South Carolina.—Assistant W. S. Edwards reached Port Royal with the schooner Bailey, on the 7th of October, 1863, and, under the orders of Admiral Dahlgren, a few days after commenced the resurvey of the bar at Charleston entrance. His soundings were made chiefly in what is known as the "Pumpkin Hill channel." The results gave a depth of twelve and a half feet at mean low water, the course in being due west, (magnetic.) Buoys were set at once by the light-house inspector conformable to the soundings. Mr. Edwards replaced the outer swash channel buoy to guide the blockading vessels, and also determined the positions of some of the buoys and obstructions in Charleston inner harbor. His party was employed until the 1st of February, when Assistant C. O. Boutelle took charge of the work, Assistant Edwards being then under orders for service on the western coast. He was aided at Charleston bar by Messrs. F. H. Dietz and L. A. Sengteller.

The acquaintance of Mr. Edwards with localities in the vicinity of Charleston was made available in verifying accounts brought by deserters from the rebel lines.

Assistant Boutelle, on arriving at the bar, made a careful study of the results given by the soundings, and prepared sailing directions to meet the changes. He also reset the buoys to the best advantage. Remarkable changes were noticed at the bar. A shoal exists now where the hulks were sunk in 1861, and on either side of it a channel with eleven feet, the depth of that in which the obstructions were placed. The Lawford channel has closed entirely, and in lieu of it there is shoal ground having only four feet of water.

Shore-line survey of Morris and Folly islands, South Carolina.—Sub-Assistant W. H. Dennis, with his party, in the schooner Caswell, reached Port Royal on the 20th of February. Preparations were then on foot for an expedition from Jacksonville, Florida. Mr. Dennis had taken up plane-table work at Port Royal, and was about a week so engaged, when request was made by Major General Gillmore that he should assist with the command of General Seymour in Florida. The Caswell sailed on the 28th. Mention will be made presently of the occupation of the party in the lower section of the coast. Mr. Dennis returned to Port Royal on the 23d of May, and made for Admiral Dahlgren a survey of the shore-line of Morris and Folly islands, and of the inland passage between Light-house inlet and Folly river. The positions of batteries were also determined and marked on maps.

The statistics of these surveys are thus given in the field report:

Shore-line surveyed	$17\frac{1}{2}$	miles.
Creeks	12	"
Marsh line	$5\frac{1}{2}$	"
Area surveyed, (square miles)	2	

Major General Foster ordered all conveniences needed by the party, and was furnished with copies of the maps.

Topography of Bay Point and Land's End, (Port Royal, South Carolina.)—While at Port Royal, in the latter part of May, Mr. Dennis made a survey, on a large scale, of Bay Point and Land's End, embracing the details within an area of about two square miles. Seven miles of shore-line were traced and marked.

This survey was made at the request of Admiral Dahlgren. The work had been commenced by Mr. W. W. Harding, of the party of Assistant Boutelle, just previous to the arrival of Mr. Dennis.

Hydrography of Light-house inlet and Folly river, South Carolina.—Sub-Assistant F. P. Webber took charge of the schooner Bailey after the departure of Assistant Edwards, and, under the direction of Assistant Boutelle, sounded out Light-house inlet from the bar inwards as far as the obstructions. He also completed the sounding of Folly river, joining his work with that done in 1862.

A chart containing the results of these surveys has been issued from the office. The soundings were completed in March.

Sub-Assistant Webber continued in service at Port Royal until June, and then took up duty in Section I. Mr. J. A. Guldin aided him in duty on the coast of South Carolina.

Service at Port Royal, South Carolina.—Assistant Boutelle placed the buoys needed in Port Royal harbor, and personally supervised the raising of the back beacon on Hilton Head. The cutting needed for bringing the beacons into view was marked out by his party.

On the 19th of March the steamer Vixen went up Beaufort river, and, taking the inland passage, conducted the gunboat Hale through into St. Helena sound. In May the party set two first-class buoys on the bar at Port Royal to replace those which had been carried away by storms.

Mr. Boutelle subsequently accompanied the naval expedition up the South Edisto river, the design of which was to co-operate with a movement of the land forces.

A revised edition of the chart of Beaufort river, South Carolina, accompanies this report as Sketch No 26.

Hydrography of the approaches to Wassaw sound, Georgia.—The part of this work remaining to be done outside of the entrance was taken up by the party of Assistant Boutelle in September, and completed in November. The hydrography now includes the northeastern approach to the bar, and in that direction the soundings made partly with the steamer Vixen and partly with the steamer Bibb are connected with the survey of Savannah river entrance. During the temporary absence of Mr. Boutelle from the section the work was conducted by Acting Master Platt, the executive officer of the steamer Bibb. In preliminary form the results are shown on Sketch No. 27.

Tidal observations.—A self-registering tide-gauge was set up at the wharf at Bay Point, Port Royal sound, by Assistant Boutelle, and observations were begun August 22. The position being, however, too much exposed, the record was frequently interrupted, and the gauge will be removed to a more sheltered ocality.

The observations made last year at the light-ship on Martin's Industry shoal with the pressure tide-gauge have been compared in the office with those made simultaneously on shore. The comparison was quite favorable. Twenty-eight high waters and twenty-nine low waters were observed at both places, and gave a probable error of twelve minutes in the times and 0.2 foot in the heights for the difference of a single observation from the mean.

SECTION VI.

FROM ST. MARY'S RIVER TO ST. JOSEPH'S BAY, INCLUDING THE EASTERN AND PART OF THE WESTERN COAST OF FLORIDA, WITH THE FLORIDA REEFS AND KEYS.

The work of the season in this section was confined to the upper part of the eastern coast of Florida, and principally to the St. John's river. As in many other instances, the topography and hydrography executed, though availing as work done in the regular progress of the survey, was of special interest at a juncture in military and naval operations. Appendix No. 1 contains a summary of the work, which will be now referred to in more detail.

Topography near Jacksonville, Florida.—Sub Assistant Dennis reported to Brigadier General Seymour, at Jacksonville, early in March, and on the invitation of that officer joined his staff and went with the expedition to Pilatka. There he surveyed all the ground held by the government forces, and assisted in laying out the line of defences. The aid of the party, Mr. S. P. Holt, in the schooner Caswell, had been meanwhile employed in extending the survey about Jacksonville. Mr. Dennis rejoined the party on the 23d of March, and continued plane-table work until the 23d of May, when the area deemed important for defensive purposes had been mapped. In connexion with this duty he made, at the request of General Birney, a reconnaissance of the roads leading from Jacksonville to St. Augustine, to Picolata, and to Mayport Mills. After being relieved from service in the St. John's river, the Caswell returned to Port Royal, as already stated.

Assistant Boutelle was furnished by this party with the results of a shore-line survey of the mouth of the St. John's river. While engaged in the reconnaissance referred to, Sub-Assistant Dennis traced one hundred and seventeen miles of road. The statistics of the detailed surveys are as follows:

Shore-line	7½	miles.
Roads	44½	"
Creeks	9	"
Marsh-line	13½	"
Area surveyed, (square miles)	9¼	

The field sheets of this work have been inked, and are now at the office. Mr. Dennis returned with his party to New York on the 30th of June, and then took up plane-table duty in Section I, as mentioned under that head. His services in Florida have been fully acknowledged in a communication from General Seymour. Mr. Dennis, while mapping ground beyond the picket-lines at Pilatka, twice barely escaped capture. His vessel, the schooner Caswell, was in tow behind the United States steamer Harriet A. Weed, when that vessel was totally destroyed by the explosion of a rebel torpedo on the 9th of May, in St. John's river.

Service with the direct tax commission in Florida.—The request made at the close of last season by the chairman, that the services of a topographer should be continued during the stay of the commissioners in Florida, was met by the assignment of Mr. R. E. McMath in March. Under instructions given by the chairman at Fernandina, Mr. McMath proceeded to St. Augustine, and there constructed a map of Nassau county, showing the land sections, their numbers, subdivisions, contents, and other particulars, as developed by the township plats of the United States land surveys. He also made a tracing from the map of Duval county, containing roads and other features additional to those in existence when the map was constructed. Through Sub-Assistant Dennis this tracing was transmitted to Brigadier General Gordon, that officer being then in command of the military forces at Jacksonville.

Before returning from this section, Mr. McMath compiled and sent to the office a sheet showing on a reduced scale the four counties adjacent to the lower part of the St. John's river. This with other material was used for the issue of an improved map of the northern part of Florida, from the office in June.

The occupation of Mr. McMath during summer and autumn has been referred to under the heads of Section I and Section III.

Hydrography of the St. John's river, Florida.—The surveying steamer Vixen, with the party of Assistant Boutelle, accompanied the naval and military expedition that went up the St. John's river in February. Acting Master Platt buoyed out a new channel for entering, which had opened to the southward of the old channel. Mr. Boutelle had previously marked the bar. He subsequently adjusted signal lanterns, so that vessels might cross at the night tides. Mr. Platt took in the steamer Mahaska, and was followed by Mr. Harding with the Dai Ching. The party then went to the assistance of the Ben Deford, army steamer, that vessel having grounded, and piloted her into the channel. On the way up to Jacksonville the channel was marked by the party in the Vixen, and signals were at the same time erected for a new hydrographic survey, to extend, if practicable, from the bar to a point five miles above the town. This resurvey was specially requested by Admiral Dahlgren, as, owing to natural changes, vessels belonging to the naval and transport service had much difficulty in getting up to Jacksonville after crossing the bar. While sounding, Assistant Boutelle went to the assistance of the Pawnee, and the service of his party in getting her afloat was duly acknowledged by Captain Balch. The hydrography was pushed at intervals under many disadvantages, and was finally concluded in May at Mayport Mills.

Mr. Boutelle gave personal attention to the placing of beacon-lights at the mouth of the St. John's river, and for that and other service was in communication with the officers of the Light-house Board.

Messrs. W. W. Harding, A. R. Fauntleroy, L. L. Nicholson, and C. P. Dillaway served as aids in the hydrographic party.

The Vixen was brought down the St. John's river soon after the disaster which met the army boat H. A. Weed. Acting Master Platt, of the party of Assistant Boutelle, noticing slight ripples on the water, and supposing them to be caused by torpedoes, was sent to examine the place. He succeeded in bringing up one of six, and it was delivered to Admiral Dahlgren. The positions of the others were pointed out to the picket-boats, and notified also to Captain Balch, of the Pawnee.

Magnetic observations at Key West.—These have been continued throughout the year in charge of Mr. Samuel Walker. The original photographic traces of the three instruments and their hourly measures are preserved in the archives for future discussion. The series of observations now extends over a period of four years and a half. It is designed to include, in all, one-half of the eleven-year period in the secular variation.

SECTIONS VII, VIII, IX.

FROM ST. JOSEPH'S BAY, FLORIDA, WESTWARD TO THE RIO GRANDE, INCLUDING PART OF THE WESTERN COAST OF FLORIDA, AND THE COAST OF ALABAMA, MISSISSIPPI, LOUISIANA, AND TEXAS.

Including some reconnaissance duty on the coast of Texas, all the work to be described under this head was in connexion with military or naval operations. Two parties were engaged for the army of the Ohio; four for the army of the Cumberland; two for the Mississippi squadron and army of the Tennessee, and two served with the army of the Gulf. Appendix No. I shows in tabular form the character of the service in each locality. The work of each party will be now described.

Topographical survey of the vicinity of Knoxville, Tennessee.—Major General Foster having requested the detail of two officers of the Coast Survey for service with his command in East Tennessee, Sub-Assistant Rockwell and Mr. R. H. Talcott were directed to report at Cincinnati in the latter part of November, 1863. After a toilsome journey by way of the Cumberland Gap, the party reached Knoxville with their instruments on the 11th of December. Next day, under the immediate orders of Captain O. M. Poe, then chief engineer in the department of the Ohio, a plane-table survey was begun of all the grounds of approach towards Knoxville. A base line of about fifteen hundred metres was measured, and signals were set up and determined in position by means of the plane table. The area to be included lay on both sides of the Holston river. Mr. Rockwell took the north side, and his survey was made to include the city of Knoxville and the heavy fortifications, with the contour of the ground which they commanded. Mr. Talcott surveyed the southern approaches, which are more hilly, and quite thickly wooded. One peculiarity of the region under notice is the numerous "sink holes" through which the smaller streams disappear suddenly, to the surprise of the topographer.

The map of the survey around Knoxville comprises about thirteen square miles. The part assigned to Mr. Talcott being complete in the middle of February, he was detached by General Foster, and after turning in his plane-table sheet at the office he retired from the service, with the cordial esteem that had been won by his abilities and genial disposition. Sub-Assistant Rockwell remained in the department of the Ohio until relieved from duty by Major General Schofield on the 2d of June.

Several copies of the map of the vicinity of Knoxville were made by Mr. Rockwell, and furnished to commanders of different branches of the military service at that post.

Topographical survey of Strawberry Plains, Tennessee.—Sub-Assistant Rockwell was employed in April and May with a plane-table survey of Strawberry Plains. When the field-work was complete, the original sheet was inked and sent to the office of the adjutant general, at Knoxville.

Topography of the vicinity of Nashville, Tennessee.—When the headquarters of the military division of the Mississippi were removed to Nashville, Sub-Assistants F. W. Dorr and J. W. Donn were directed to make a topographical survey of its vicinity. Before taking up this work, Mr. Donn, under the orders of Major General Smith, examined the various branches that fall into the Cumberland river from the south between Nashville and the South Fork. This was for the purpose of finding a nearer route than the one which had been used for supplying the army at Knoxville. A detailed report of the reconnaissance was addressed to General Smith. At his return Sub-Assistant Donn took up the survey on the north side of Nashville, Mr. Dorr at the same time being engaged in mapping the southern approaches and the environs of the city, which service he commenced on the 3d of February. He was joined by Mr. Donn on the 22d, and working jointly the survey was concluded by the 18th of March.

Sub-Assistant Dorr was during the summer engaged in topographical duty in Section I, and Mr. Donn in connexion with the military forces near Petersburg, Va., as stated under the head of Section III.

The following are statistics of the survey at Nashville:

Roads traced	$92\frac{1}{2}$	miles.
Creeks	$50\frac{1}{2}$	"
River shore-line	20	"
Area surveyed, (square miles)	23	

Topography of Chattanooga, Tennessee.—Previous to the forward movement of the army from its base at Chattanooga, the ground occupied by the defences and the country adjacent were surveyed and carefully mapped by Sub-Assistant Dorr; Sub-Assistant Donn at the same time made a topographical survey of Moccasin Point and of Raccoon mountain, the valley to the eastward of it, and the Lookout mountain and valley. This work was completed at the end of December, and was undertaken at the request of the chief engineer of the army of the Cumberland, General W. F. Smith. Assistant P. C. F. West, on reporting to the chief engineer, was attached to his staff, and entered on the discharge of duties with which he had become familiar in previous campaigns with the same commander. He took part in the movement at Brown's ferry, examined the banks of the Tennessee river lower down, and by way of Kelly's Ferry gap extended his reconnaissance through the mountains to Whiteside. The ground between the North Chickamauga and Brown's ferry was also examined, the object being to find routes for concealing from the enemy the intended movement of troops and the use of pontoons. Captain West was present in the battles before Chattanooga in November, and acted on the staff of General Smith in the pursuit of the enemy to Ringgold. His subsequent connexion with the same command has been referred to under the head of Section III.

The plane-table sheets of the survey made by Messrs. Dorr and Donn comprise the following statistics:

Roads surveyed	169½ miles.
Creeks	103¼ "
Area of topography, (square miles)	44½

About twenty-seven miles of the course of the Tennessee river are included on the two sheets. The survey was commenced in the latter part of October, and was completed in the middle of January. All the ground passed over by the two topographers is marked by contour lines on the map, indicating successive elevations of twenty feet.

Sub-Assistant Fendall also reported at Chattanooga in October. Being then under orders for duty with the Mississippi squadron, his stay was limited to the time sufficient to reconnoitre the country for a road across Raccoon mountain, from Kelly's ferry to Whiteside. After performing this service he proceeded to Vicksburg.

The journey of the parties assigned to service at Chattanooga was attended with unusual difficulties, arising in part from the scarcity of forage for the animals used in transportation, and partly from the almost impassable condition of the roads between Stevenson and the ground occupied by the army.

Survey of Chickamauga battle-ground, Georgia.—Sub-Assistant C. H. Boyd was detailed for field service in December, to meet an application from General W. L. Elliott, chief of cavalry in the army of the Cumberland. On reaching Chattanooga he reported to Major General Thomas, and was at once attached to the staff. In addition to the duties assigned at headquarters, Captain Boyd at the end of January commenced a triangulation of the country south of Chattanooga, to include the battle-ground of Chickamauga. A base was measured, and points were determined in the usual way by the theodolite at seventeen stations. A topographical survey being ordered by Major General Smith, chief engineer, that duty was taken up without delay. Mr. Boyd's plane-table sheet includes about fifty square miles, and takes in all the ground occupied by the contending forces at the battle of Chickamauga. On another topographical sheet he traced the defensive lines and works around Chattanooga, and drew range-marks for the chief of artillery.

These surveys and duties in the line of military service occupied the time of Captain Boyd until the end of July. He then reported to the office in Washington, and there deposited the notes of his field-work and the plane-table sheets referred to.

Service with the Mississippi squadron.—The party of Assistant F. H. Gerdes has now completed three successive terms of service under the orders of Admiral Porter. That of the present season includes several important surveys on the Mississippi, on the Ohio, and on Red river, which will be best described under separate heads.

After conferring personally with the flag-officer, in October, 1863, and leaving Sub-Assistant Clarence Fendall in the section, Mr. Gerdes returned to New York. He joined the squadron at Mound City at the end of January following, with two aids, Messrs. T. C. Bowie and J. B. Adamson. Sub-Assistant F. F. Nes was assigned to service with this party, but was compelled to return by serious illness contracted at Cairo.

Before taking up duty for the squadron, Mr. Fendall met the call of the chief engineer of the army at Chattanooga for topographical service, and reported to the admiral on the 14th of November.

Of the surveys made during the season terminating on the 1st of July, those on the Mississippi will be first mentioned.

Reconnaissance between Rodney and Palmyra bend.—The result of this reconnaissance is a map showing on a large scale about fifty miles of the course of the Mississippi, its main channels, shoals, bars, the single plantations on its banks, the distinction of woods and cultivated grounds, towns, hills, swamps, the landings, roads leading into the interior east and west, the usual crossing-places, and many other features. In this work the party of Assistant Gerdes was occupied four weeks during April and May. The map has been inked, and is now at the office in Washington. An engraved reduction of it is given with this report. (Sketches Nos. 29 and 30.)

Topographical and hydrographic survey at Grand Gulf, Mississippi.—For this survey Mr. Gerdes had the use of the armed steamer Curlew, and force sufficient to resist the attacks of guerilla parties that would otherwise have rendered it impracticable. The topographical sheet shows the rebel and national lines of fortification, the peaks and spurs of hills which mark the banks of the Mississippi at Grand Gulf, and all the natural and artificial features in the vicinity of the town. The entire bend of the river was carefully sounded and permanent bench-marks were established for future reference. All the soundings taken were reduced to an approximate medium stage of the river, or about thirteen feet above the level of ordinary low water. This survey was commenced on the 15th of March, and completed on the 16th of April. The party while at work was frequently fired on by guerillas.

Survey at Vicksburg, Mississippi.—Before the close of the preceding season Sub-Assistant Fendall had nearly completed his survey of the approaches to Vicksburg. The supplementary work, then prevented by illness, was resumed in November, 1863. At the request of Admiral Porter a picket guard and transportation were furnished by General McPherson, and with these facilities the survey was finished on the 4th of December. More particular reference was made to this work in my report of last year. The map includes not only the river defences, but also the rebel lines of fortification against General Grant's approach, and the topographical features of the country included within them.

Topography and hydrography at Cairo and Mound City, Illinois.—This survey was commenced by Mr. Fendall, in December, with a party in the small gunboat Alexandra. After the arrival of Assistant Gerdes, in January, a triangulation was laid out to include the entire course of the Ohio river from Mound City to Cairo, and points were occupied on the Kentucky shore; but several surveys being ordered soon after, the work was suspended until the 29th of May. Mr. Fendall had then returned from the Red river, and Mr. Gerdes had completed work on the Mississippi. With the entire force of his party the survey of the Ohio was pushed to completion before the end of June. The small steamer Tensas was used in making the soundings. The map was constructed without delay, and a copy of it was furnished to Admiral Porter. It embraces (see sketch No. 31) all the topographical details of about seven miles of both shores of the Ohio and the river hydrography. Assistant Gerdes made also, at the request of the admiral, a special survey of the naval depot, and subsequently a chart of the harbor and river front at Mound City, and presented the results in the form of maps on a large scale.

Topographical surveys on Red river, Louisiana.—Quarters being provided for him on the flag-ship Black Hawk, of the Mississippi squadron, Sub-Assistant Fendall went on board on the 20th of February, and accompanied the expedition up the Red river. By direction of Admiral Porter he made a survey of Semmesport, on the Atchafalaya, and subsequently of the vicinity of Fort DeRussy. By the 4th of April he had finished an extensive topographical survey of the country around Alexandria, La., including the course of the Red river from the town as far up as the falls. Later he compiled for the use of the squadron sketches of the route from Alexandria to Grand Ecore, taking the requisite observations from a light-draught steamer. The vessel was several times attacked by the enemy, and received numerous shots in her hull and upper works.

Mr. Fendall was again at the mouth of Red river on the 1st of May, and returned with the flag-ship to Mound City. He reported at the office on the 29th of June.

Copies of all the surveys made by the party, working either jointly or separately, were furnished to Admiral Porter. The personal risk incurred in prosecuting the work was considerable. While returning from Grand Gulf the vessel of Assistant Gerdes had to engage a rebel battery of twelve guns at a point near Gaines's Landing, on the Arkansas shore of the Mississippi. The vessel was struck nine times by solid shot or shell, and several rifle balls passed through her cabin.

On taking leave of the squadron Assistant Gerdes and Sub-Assistant Fendall received written testimonials from the flag-officer expressing his satisfaction, and urging the return of the party in the fall for completing the reconnaissance of the Mississippi, on the plan adopted by Mr. Gerdes, between Rodney and Vicksburg. The utility of this service, so long as guard vessels are needed on that river, is obvious. It will be resumed by the party when preparations now under way are completed.

Surveys in Louisiana and Texas.—At the date of my last annual report Assistant J. G. Oltmanns was attached to the staff of Major General Franklin, and was proceeding with the 19th army corps in the Red river campaign. Before leaving New Iberia he made a military map of its approaches to show also the positions of the different corps, divisions, picket lines, &c. A survey of the same character was made at Franklin in the latter part of December, and in the following month reconnaissances to Côte Blanche bay over a district with which the previous operations of Mr. Oltmanns on Coast Survey duty had made him familiar. He accompanied the army to Alexandria in March, and, with an escort, advanced beyond that post and found the picket lines of the enemy. At Natchitoches, where the army halted, he made a preliminary survey of the approaches, and of the ground occupied. Mr. Oltmanns served as aide-de-camp in the encounter with the enemy at Sabine Cross Roads, in which the bridle was cut away from his hand by a shell; and in the battle at Pleasant Hill, which checked the rebel advance. He made a survey of the intrenched ground at Grand Ecore, at the junction of Red river and Old river, and connected it with the survey of Natchitoches. On the return of the army to Alexandria he was actively engaged in staff duty, and in making quick reconnaissances for verbal report. He accompanied the staff of Major General Franklin to New York in July, the wound received by that officer at Sabine Crossroads having compelled him to leave the department. Assistant Oltmanns was in continuous service with the army in Louisiana during twenty-one months. He returned to the office in August last, and in September joined the army in the Shenandoah valley, in Virginia.

Sub-Assistant Charles Hosmer reported to Major General Banks at New Orleans on the 22d of October, 1863. He was present for duty at Brazos Santiago in November, but was recalled to attend the army detachment at Aransas Pass, where he determined the changes which had occurred on that bar, and located and marked on a map the position of the rebel defences. At Pass Cavallo the same kind of service was rendered. He traced also the changes in shore-line at the eastern end of Matagorda island, mapped the Pelican islands, and buoyed out the channel into McHenry bayou. At the request of Brigadier General Grover Mr. Hosmer joined his staff at Franklin, La., early in January, after recovering from illness contracted in duty on the coast of Texas. In the course of the next two months a survey was made of the vicinity and defences of Madisonville, in the erection of which Mr. Hosmer assisted. As in all similar cases, the map of this survey was sent to the chief engineer, Major D. C. Houston. Mr. Hosmer then rejoined the staff, attended General Grover on a visit to Thibodeaux, and accompanied him to Alexandria in the movement which was made up the Red river. On the return of the army, a topographical sketch of the vicinity of Morganza was made for Brigadier General Emory. Similar duty was performed at Fort Adams, Miss., Mr. Hosmer having accompanied the army division to that post in June. Returning to Morganza in the latter part of the month, he proceeded to New Orleans with General Grover, and, on his arrival, was relieved from service in the department of the Gulf.

Sub-Assistant Hosmer, after reporting at the office, joined the party of Assistant Harrison, as stated under the head of Section I. He has furnished to the office copies of all the surveys which he made for military use in Louisiana and Texas.

SECTION X.

FROM SAN DIEGO OR THE SOUTHERN BOUNDARY ON THE PACIFIC TO THE FORTY-SECOND PARALLEL, INCLUDING THE COAST OF CALIFORNIA.

The work on the western coast will be described in the reverse geographical order, or from south to north, contrary to the order observed in the preceding part of this report. Appendix No I shows the arrangement of the parties, the persons employed, and their sites of work. The different surveys will here be referred to in detail.

Coast triangulation north of Monterey bay, California.—The party of Assistant W. E. Greenwell took the field on the 1st of April at Monterey bay. After connecting the primary triangulation with Point Pinos and Santa Cruz stations, the coast triangulation was continued northward and westward to stations above Point Año Nuevo. The points used by the topographical parties in tracing the coast line in former years were included as far as practicable in this triangulation. Field-work was continued until the middle of October.

Sub-Assistant Julius Kincheloe was attached to the party, and effectively co-operated in its duties.

The following is a summary of the statistics:

Signals erected	28
Stations occupied	26
Objects observed on	31
Number of observations	3, 668

The angles were measured with the theodolite No. 44.

Triangulation westward of Santa Barbara, California.—The party of Assistant Greenwell were still in the field when my last annual report was closed. About eight miles of the coast triangulation, westward of Santa Barbara, was added to the work previously reported, before the return of the schooner Humboldt to San Francisco.

The following are the statistics:

Signals erected	10
Stations occupied	10
Angles measured	31
Number of observations	908

Sub-Assistant Kincheloe assisted in this work. Ten volumes, containing the original records of the triangulation about Santa Barbara, have been received from Assistant Greenwell during the present season.

Triangulation of Suisun bay, California.—The triangulation of Suisun bay was commenced on the 28th of July by Assistant J. S. Lawson, with a party, in the brig Fauntleroy.

Almost the entire shore-line of the bay is bordered by marsh, off which are extensive flats of very soft mud. By taking advantage of high water the reconnaissance was successfully made, and points were determined for the use of the hydrographic party. Mr. Lawson erected ten signals, and by the 1st of September had occupied two stations with the theodolite, and measured twenty-two angles by nine hundred and fifty-two observations. The triangulation is yet in progress. A stretch of about nine miles will be included in the triangulation work of the present season.

Mr. C. B. Boutelle aided in the party of Assistant Lawson until the 1st of May, and was then transferred to the hydrographic party of Assistant Edwards.

Hydrography of Half Moon bay, California.—This work was commenced by the party of Assistant A. F. Rodgers on the 11th of September, 1863, and was completed on the 23d of the following month.

To the southward of the ordinary course to the anchorage under Point Miramontes Mr. Rodgers developed a dangerous ledge of rocks extending about half a mile in a direction parallel to the coast, and nearly two miles off shore. The reef has an average depth of three and a half fathoms, but is much broken, and is marked at its southern end by a rock with only four feet of water.

Of Half Moon bay as a harbor Assistant Rodgers reports as follows: "The anchorage is not much to be recommended except as an alternative, although the approaches to it are plain, and the water between the reef and the beach bold, and shoaling gradually on either hand, so as to make it easy by the use of the lead to reach the anchorage without risk. There is no shelter except from northwest winds, and with these a heavy sea rolls over the reef and reaches the anchorage." * * * "The holding ground is bad, being apparently of sandstone formation without deposit, or, if any, so slight as to be useless in holding an anchor."

For determining the positions of signals to be used in the hydrographic work Mr. Rodgers made a supplementary triangulation. His party erected nine signals. From the stations marked by them thirty-four angles were measured by six hundred and ninety observations. The statistics of the hydrography which is comprised on three sheets are thus reported:

Miles run in sounding	428
Angles measured	2,000
Number of observations	15,327
Area sounded, (square miles)	$54\frac{3}{4}$

Assistant Rodgers highly commends the services rendered by his aid, Mr. Alex. Chase.

The original sheets of the hydrographic survey of Half Moon bay were inked in the course of the season, and are now on file in the office. Assistant Rodgers remarks in closing his report: "Half Moon bay is the shipping point for a large and fertile farming country, some five thousand tons of produce being freighted thence to San Francisco every season. An unbroken view of fields of wheat, oats, barley, and potatoes, which are the staples, and which grow with luxuriance, attests the fertility of the soil. It is cultivated to the very edge of the bluffs which overhang the coast for a distance of twenty-five miles north and south of the anchorage."

Resurvey near Mare island navy yard.—At the request of the commandant the channel of Mare Island strait, opposite to the navy yard, was resurveyed in March by Assistant Rodgers, with a view to determine the extent of changes that might have occurred, and to facilitate the operations necessary in dredging. In making the requisite soundings two hundred and forty-nine positions were determined, and nearly five thousand casts were made with the lead. The hydrography included the entire breadth of the strait from the northwest end of the island down to the junction of Mare island and Karquines straits.

Assistant Lawson, being then in the vicinity of Mare island, co-operated in this survey, as did also Assistant Edwards, who arrived in the section before the soundings were completed.

Assistant Rodgers was called upon in November to make a hydrographic survey around the ship Aquila, that vessel having sunk at San Francisco with a valuable freight. This was promptly done, and the results, showing the best mode of proceeding in order to save the plates of the monitor Camanche, were furnished to the naval authorities.

Hydrography.—On the 1st of March Assistant W. S. Edwards was assigned to duty on the western coast, with instructions to take charge of the schooner Marcy, and to succeed Assistant Rodgers in the direction of the hydrographic work. He proceeded at once to San Francisco, and prosecuted some supplementary duty in Mare Island strait, in order to furnish reliable data for dredging operations contemplated at and near the wharves of the navy yard. Tracings from the sheet of soundings were furnished in June to Commander Selfridge, United States navy, commandant of the yard.

Early in August Mr. Edwards set up signals, and commenced the hydrography of Suisun bay, following the preliminary survey which was begun at the same time by Assistant Lawson. Soundings were continued during a fortnight, but were suspended to meet the request of Commandant Selfridge for information concerning the mud flat between San Pablo Point and Pinole Point, in San Pablo bay, where the United States storeship Farallones was ashore. The flat was examined by Assistant Edwards, and a comparative chart showing his soundings and those made by Commander Alden in 1854 was furnished to the commandant.

On the 4th of September the party in the Marcy took up the off-shore hydrography between Point Piedra and Point Año Nuevo, and at the date of the last report by Assistant Edwards was still engaged in its prosecution.

The hydrography of Suisun bay will be resumed and completed if practicable during the winter.

Mr. C. B. Boutelle joined the party as aid on the 1st of May.

New editions of the reconnaissance charts of the western coast are given with this report, (Sketches Nos. 32, 33, and 34,) and a general chart of the coast between Point Pinos and Bodega Head, as Sketch No. 35.

Tidal observations.—The self-registering tide-gauges at San Diego and San Francisco were kept at work successfully by Messrs. A. Cassidy and H. E. Uhrlandt, under the general supervision of Captain G. H. Elliot, of the corps of engineers.

Mr. Uhrlandt has also read off, as heretofore, all the records of the self-registering tide-gauges of the western coast.

SECTION XI.

FROM THE FORTY-SECOND PARALLEL TO THE NORTHWESTERN BOUNDARY OF THE UNITED STATES, INCLUDING THE COAST OF THE STATE OF OREGON AND THE COAST OF WASHINGTON TERRITORY.

The party usually assigned to duty in this section having completed the survey to be noticed under the following head, took up service in Section X. Its labors there have been referred to in the preceding chapter.

Triangulation and shore line survey of Koos bay, Oregon.—The survey of Koos bay was in progress when my report of last year was closed. In addition to the work then reported, Assistant J. S. Lawson occupied seven stations, and measured ninety-three angles by two thousand five hundred and twenty-six observations with the ten-inch Gambey theodolite No. 20. A preliminary topographical survey made at the same time comprises forty-one miles of shore-line, and nineteen miles of outline of marsh.

The following is an extract from the concluding report of Assistant Lawson:

"From North Bend to the head of Koos bay there are but two narrow channels. The main one and the only one available for vessels of any draught is quite close to the western shore, and leads into the slough on which the coal mines are situated. The other lies on the eastern side and is narrow. In some places it approaches near to the shore, and in others winds through the flats, which are bare at low water, and embrace nearly all of this part of the bay. This channel is used only by boats. It leads directly into Koos river, which empties into the southeast end of the bay. Across the head of the bay there is a third channel connecting the two just described, but it is of no importance. Near the mouth of the river there are several snags that narrow the channel, and give it an irregular course."

"Along the line of low water in each of these channels small signals were placed from one hundred to three hundred metres apart. These, in running the shore-line of the bay, were determined in position by the plane table. The same was done in other parts of the bay where the flats extended any considerable distance from the shore, as off Pony Point."

Assistant Lawson completed at San Francisco the office work connected with the triangulation of Koos bay, and forwarded the sheet containing the shore-line survey. His subsequent work has already been referred to.

Tidal observations.—The station at Astoria, Oregon, has remained in charge of Mr. L. Wilson, under the general supervision of Captain G. H. Elliot, United States engineers. The very complete meteorological record kept by Mr. Wilson deserves special mention.

COAST SURVEY OFFICE.

The office in Washington has remained under the supervision of *J. E. Hilgard, esq.*, the assistant in charge. *Professor F. A. P. Barnard* acted as general assistant until the 1st of June, and then accepted the presidency of Columbia College. Full details are given in the report of the assistant in charge (Appendix No. 10) in regard to occupation in each division of the office. A short abstract of that report is here appended.

Hydrographic division.—The duties of this section of the work, including the care and outfit of vessels for the use of field parties, have been directed, as heretofore, by *Captain C. P. Patterson.* The general occupation consists of the verification of original hydrographic sheets, the preparation of sailing directions, the revision of published charts when new material is received, and the ordinary routine required for keeping hydrographic publications up with the latest information.

Two draughtsmen, *Messrs. Arthur Balbach* and *Louis Karcher*, have been attached to this division, the last named until the end of September, when he retired from the office.

Tidal division.—In this branch of the office tidal notes are adjusted for each of the hydrographic charts as they pass into the engraving division. *Assistant L. F. Pourtales*, in charge of the tidal division, attends also to the arrangements needful for keeping up observations at the permanent tidal stations on the coast. A report on the records received during the year is given in Appendix No. 10.

Mr. P. H. Donegan was on duty in the division until the 1st of April, when he was replaced by *Mr. John Downes.* The ordinary reductions and copying from the tidal registers have been done by *M. Thomas* and *F. R. Pendleton.*

Computing division.—The report of *Assistant Charles A. Schott*, who retains the charge of this division, (Appendix No. 10,) states the occupation of each of the computers. *Mr. James Main* resigned his place in the division on the 1st of August. *Mr. R. S. Avery*, formerly attached to the tidal division, has served as computer during the year, as have also *Assistant T. W. Werner, Mr. E. Nulty*, and *Dr. Gottlieb Rumpf.* The clerical duties of the division have been performed by *Mr. E. Courtenay*, and *R. Freeman* has made transcripts of miscellaneous computations.

The report of Mr. Scott gives details in regard to several interesting subjects referred to him in the course of the year, and which were exclusive of the direction of work in the computing division.

Drawing division.—Under the direction of *Assistant J. E. Hilgard* the distribution of work in this branch of the office has been made by *Mr. W. T. Bright.* Of the draughstmen employed, *Assistant M. J. McClery, Mr. E. Hergesheimer*, and *J. W. Maedel*, (the last named until December, 1863,) were engaged in preparing photographed reductions for the map engravers, *Mr. L. D. Williams* in miscellaneous work until the end of November, 1863, when he resigned. *Mr. A. Lindenkohl* has been chiefly employed in the compilation of military maps, and *Mr. H. Lindenkohl* in making projections when not engaged for the lithographic division. *Mr. F. Fairfax* has been employed in ordinary reductions from plane-table sheets, and *Messrs. E. Willenbucher* and *W. B. McMurtrie* principally in plotting hydrographic woik. *Messrs. B. Hooe, W. Fairfax, J. H Logan*, and *D. Koch* have made the tracings called for during the year, the last named until October, when he was replaced by *Mr. H. Custer.*

The details of work done by each of the draughtsmen are stated in the Appendix No. 10.

Engraving division.—The force in the engraving division has been directed, as heretofore ,by *Mr. Edward Wharton.* The topographical engraving has been executed by *Messrs. A. Rolle, J. Enthoffer, A. Sengteller, W. Phillips, H. C. Evans, H. S. Barnard, A. M. Maedel, R. F. Bartle*, and *W. A. Thompson; Messrs. J. Knight, E. A. Madel, and W. H. Davis* have been employed in lettering, and *Messrs. J. C. Kondrup, A. Petersen, F. W. Benner, E. H. Sipe, and J. G. Thompson* in miscellaneous engravings. The use of punches for soundings in lieu of cut figures has been continued by *Mr. A. Buckle.* The clerical service required in the division was performed at successive periods of the year by *Mr. G. J. Pinckard, Mr. H. C. Saxton*, and *Mr. George C. Schaeffer, jr.* Appendix No. 10 contains a synopsis of the work done by each engraver.

Photograph and electrotype division.—A summary of the work done in this part of the office is given in the report of *Mr. George Mathiot.* (Appendix No. 10.) In several instances during the year the facility afforded by the photographic process has availed for the speedy issue of maps, which could not have been otherwise produced in the time allotted for their issue.

Lithographing division.—Until June the operations in this section of the office were directed by *Professor F. A. P. Barnard*, who also had charge of the map printing. The work in both branches has since been under the supervision of *Mr. W. W. Cooper*, whose report will be found appended to that of the assistant in charge of the office, in Appendix No. 10.

Mr. C. G. Krebs has been employed during the year as lithographic engraver, and *Messrs. Archibald, Brown* and *James Ruhl* as printers. The drawings required in the division were made by *Mr. A. Lindenkohl*, assisted by *Mr. H. Lindenkohl. Mr. E. Molitor*, temporarily attached to the drawing division, aided also in lithographing.

Map printing.—An aggregate of sixty-five thousand eight hundred and ninety-seven copies of maps and charts have been printed during the year. Of this number two-thirds were hydrographic charts, printed in part from the copper plates, and partly by the transfer process. The copper-plate press has been worked as heretofore by *Mr. John Rutherdale*. More than twenty-two thousand copies of military maps and sketches were printed in the course of the present year. The series of lithographic maps now comprise nearly the entire area of the rebellious States that lie east of the Mississippi. The lithographic presses on which the maps are printed have been worked by *Messrs. Brown* and *Ruhl.*

Distribution of maps and annual reports.—Of the maps and charts printed during the year, fifty-three thousand seven hundred copies have been distributed to the navy, to captains and pilots employed in the transport service, to military officers, sale agents, and civilians. Of that aggregate thirty-six thousand six hundred and ninety-seven copies were hydrographic charts. A summary of the distribution by *Mr. M. T. Johnstone,* who remains in charge of the map-room, is given in the Appendix No. 10, together with a statement in reference to the distribution of copies of the annual reports.

Of the number of sheets of military maps printed during the year, seventeen thousand copies were issued from the office. The record of this distribution is kept by *Mr. V. E. King.*

To *Samuel Hein, esq.*, the disbursing officer of the Coast Survey, and to *Captain C. P. Patterson,* hydrographic inspector, my special acknowledgments are due for constant interest in the work, and for their effective co-operation.

My principal clerk, *W. W. Cooper, esq.*, has acceptably performed his usual office duties in addition to those already mentioned, and *Mr. J. T. Hoover* the clerical service with the superintendent in the field.

Respectfully submitted by

A. D. BACHE,
Superintendent United States Coast Survey.

Hon. WILLIAM P. FESSENDEN,
Secretary of the Treasury

APPENDIX.

APPENDIX No. 1

Distribution of the parties of the Coast Survey upon the coasts of the United States during the surveying season of 1863–'64.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I.				
From Passamaquoddy bay to Point Judith, including the coast of Maine, New Hampshire, Massachusetts, and Rhode Island.	No. 1	Triangulation	G. A. Fairfield, assistant; H. Anderson, aid	Triangulation of Union River bay completed, and connected with that of Great Blue Hill bay. (See also Section IV.)
	2	Triangulation	S. C. McCorkle, assistant	Triangulation of Penobscot river extended from North Bucksport upwards, to Bangor.
	3	Topography	W. H. Dennis, sub-assistant; S. P. Holt, aid.	Preliminary survey of the eastern and north shore of Deer island (Passamaquoddy bay) and of the ledges between it and White Horse island. (See also Sections V and VI.)
	4	Topography	F. W. Dorr, sub-assistant; Frank Granger, aid.	Shore-line survey of Manhegan and other islands at the southwestern entrance of Penobscot bay. (See also Sec. VIII.)
	5	Topography	Charles Ferguson, sub-assistant.	Plane-table survey from the Narrows southward, completing the topography of St. George's river, Me. (See also Section III.)
	6	Topography	P. C. F. West, assistant	Topographical survey of the eastern side of the Sheepscot river, Me., from Ebenecook harbor southward to Cape Newaggen, and eastward to include Booth bay harbor and the coast between Spruce Point and Squirrel island. (See also Sections III and VIII.)
	7	Topography	R. E. McMath	Detailed plane-table survey of the eastern side of the Sheepscot river, Me., completed below Wiscasset, and survey of part of Westport island. (See also Sections III and VI.)
	8	Topography	I. Hull Adams, assistant	Topography nearly completed on the shores of water passages between the Sheepscot and Kennebec rivers, Me.
	9	Topography	R. M. Bache, assistant	Detailed survey continued on the south shore of the Androscoggin between the Kennebec river and Brunswick, Me.
	10	Topography	A. W. Longfellow, assistant	Interior details filled in, completing the plane-table survey of Great Jebeig, Cousin's, Littlejohn's, and other islands, and the Cumberland shore of Casco bay; shore-line of the Gurnet traced, between Orr's and Great island.
	11	Topography	A. M. Harrison, assistant; Chas. Hosmer, sub-assistant.	Detailed plane-table survey including the shores of Warren, Barrington, and Kickemuit river and Bristol neck, with the shores of Bristol harbor and Mt. Hope bay. (See also Sections VIII and IX.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I—Continued.	No. 12	Hydrography......	F. P. Webber, sub-assistant; C. P. Dillaway, Franklin Platt, jr., Cleveland Abbé, and M. M. Defrees, aids.	St. George's river, Me., sounded, from Thomaston southward to the entrance, and junction made with inshore hydrography of the coast of Maine. (See also Section V.)
	13	Hydrography......	Alexander Strausz, acting assistant; C. S. Hein, L. A. Sengteller, aids.	Soundings in Quohog bay, Me., completed from Lovell's cove southward to Bailey's island and eastward to Small Point peninsula. (See also Section IV.)
	14	Hydrography......	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Extension of the hydrography southward and eastward from Portland entrance, and development of White Head ground, off Cape Elizabeth. (See also Sections II and IV.)
	15	Physical survey ...	Henry Mitchell, assistant....	Compilation of data derived from the special survey of Boston harbor, for the United States commissioners. Hydrographic examination in New Bedford harbor, Mass.; and for aids to navigation in Penobscot and Passamaquoddy bays.
	16	Magnetic and tidal observations.	Edward Goodfellow, assistant, (part of season;) A. T. Mosman, sub-assist't, (part of season.)	Tidal and magnetic observations continued at Eastport, Me., until August. (See also Sections II and III.)
	17	Magnetic and tidal observations.	H. W. Richardson..........	Observations at Portland with tide-gauge and magnetic instruments transferred from Eastport.
	18	Tidal observations..	T. E. Ready................	Self-registering observations continued at the Charlestown navy yard, Mass.
SECTION II. From Point Judith to Cape Henlopen, including the coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.	1	Geodetic and magnetic observations.	A. D. Bache, superintendent; G. W. Dean, assistant; R. E. Halter, sub-assistant; F. W. Perkins, J. J. Gilbert, aids.	Wooster Mountain, near Danbury, Conn., occupied, and additional observations made at Bald Hill, Conn., for connecting the Epping base in Section I with the base on Fire island. Magnetic declination, dip and intensity determined at Wooster Mountain. (See also Sections III and IV.)
	2	Triangulation	Edmund Blunt, assistant; J. A. Sullivan, sub-assistant; A. T. Mosman, sub-assistant, (part of season.)	Triangulation connecting the primary work in this Section with the triangulation of Hudson river.
	3	Triangulation	John Farley, assistant.......	Triangulation of the coast of New Jersey extended from Manasquan inlet southward to Tom's river, including the shores of Barnegat bay.
	4	Topography.......	H. L. Whiting, assistant; C. Rockwell, sub-assistant, (part of season;) H. G. Ogden, aid.	Detailed topography of Hudson river extended from Nyack and Sing Sing northward to Haverstraw and Croton village. (See also Sections III and VIII.)
	5	Topography.......	C. M. Bache, assistant; T. C. Bowie, sub-assistant.	Supplementary plane-table survey of the highlands of Navesink, N. J. (See also Sections III and VIII.)
	6	Topography.......	H. W. Bache, in charge; H. G. Ogden, aid.	Plane-table survey of Absecom inlet, N. J., including Atlantic City and Brigantine beach. (See also Sections III and IV.)
	7	Hydrography......	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Hydrography of Absecom inlet, the approaches and harbor. (See also Sections I and IV.)

APPENDIX No. 1—Continued

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION II—Continued.	No. 8	Special examination.	Henry Mitchell, assistant; J. W. Brown, A. M. Wetherill, aids.	The effect of floating ice observed in Delaware river at sites proposed for a navy yard. (See also Section I.)
	9	Tidal observations..	R. T. Bassett	Observations continued with the self-registering gauge at Governor's island (New York harbor) and with a box-gauge at Brooklyn.
SECTION III. From Cape Henlopen to Cape Henry, including the coast of part of Delaware; the coast of Maryland, and part of the coast of Virginia.	1	Astronomical observations.	G. W. Dean, assistant; A. T. Mosman, sub-assistant; S. H. Lyman, aid.	Longitude determined by telegraphic exchanges between Washington, D. C., and Martinsburg, Clarksburg, Cumberland, Grafton, Cameron, Wheeling, Parkersburg, Point Pleasant, and Gauley bridge, W. Va., and with South Point, Ohio. Observations for latitude and for the magnetic elements at the same stations, and at Charleston, W. Va. (See also Section I.)
	2	Topography	C. T. Iardella, sub-assistant; C. M. Bache, assistant, (part of season;) H. W. Bache, aid.	Plane-table survey of ground occupied for defensive purposes in the environs of Baltimore, Md. (See also Section II.)
	3	Topography	Charles Ferguson, sub-assistant.	Supplementary plane-table survey completed outside of the northeast boundary of the District of Columbia, below Bladensburg, Md. (See also Section I.)
	4	Topography	E. Hergesheimer, R. E. McMath.	Minute topographical survey of Arlington Heights, Va., and contour of the ground mapped by levelling, for the War Department. (See also Sections I and VI.)
	5	Reconnaissance	P. C. F. West, assistant	Reconnaissances west and north of Bermuda Hundred, in connexion with military duty in the army of the James river, Va. (See also Sections I and VIII.)
	6	Topography	J. W. Donn, sub-assistant; H. L. Marindin, aid.	Plane-table surveys for military purposes at Bermuda Hundred, Va. (See also Section VIII.)
	7	Topography	C. Rockwell, sub-assistant	Special topographical survey near Sewall's Point for military purposes. (See also Section VIII.)
	8	Topography	J. G. Oltmanns, assistant	Military service and reconnaissance duty with the 19th army corps in the Shenandoah valley, Va. (See also Sec. VIII.)
	9	Topography	A. Lindenkohl	Special service at Clarksburg, W. Va., in connexion with the military map of West Virginia.
	10	Hydrography	J. S. Bradford, sub-assistant	Trent's Reach (James river, Va.) sounded and charts made for the use of the North Atlantic blockading squadron. (See also Section IV.)
	11	Tidal observations..	M. C. King, (part of season;) C. Kelly.	Series of observations continued at Old Point Comfort with the self-registering tide-gauge.
SECTION IV. From Cape Henry to Cape Fear, including part of the coast of Virginia and part of North Carolina.	1	Triangulation and topography.	R. E. Halter, sub-assistant	Triangulation and topography of Roanoke river, N. C., from Ryan's Thoroughfare to the mouth. Triangulation and shoreline survey of Croatan sound, N. C. Topography of Roanoke island completed. (See also Section II.)
	2	Triangulation	G. A. Fairfield, assistant; H. Anderson, aid.	Triangulation of the Neuse river, N. C., continued in the vicinity of Goose creek. (See also Section I.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION IV—Continued.	No. 3	Hydrography......	J. S. Bradford, sub-assistant; H. M. DeWees and H. L. Marindin, aids.	Roanoke river, N. C., sounded from its mouth upward to Ryan's Thoroughfare, including also Bachelor's bay and Middle and Eastmost rivers. Hydrographic survey of Croatan sound and development of the artificial obstructions. Buoys were set in the channel from Roanoke marshes to Croatan light. Reconnaissance of Bogue sound, N. C. (See also Section III.)
	4	Hydrography......	Alexander Strausz, acting assistant; H. G. Ogden and Gershom Bradford, aids.	Hydrographic resurvey of Hatteras inlet and Beaufort harbor, N. C. Hydrography of the Neuse river commenced in the vicinity of New Bern, and buoys set to mark the channel. (See also Section I.)
	5	Hydrography......	Edw. Cordell, acting assistant; A. M. Wetherill, J. W. Brown, and Franklin Platt, aids.	Hydrography of Core sound, N. C., completed, and channel marked by buoys from Bogue sound through the Strait. Resurveys of the entrance to Beaufort harbor, N. C., and of Hatteras inlet. General duty in the Section for the Light-house Board.
	6	Hydrography......	Lieut. Comdr. T. S. Phelps, U. S. N., assistant.	Development by reconnaissance soundings of the Cape Lookout shoals. (See also Sections I and II.)
SECTION V. From Cape Fear to St. Mary's river, Ga., including the coast of part of North Carolina, and the coast of South Carolina and Georgia.	1	Hydrography......	W. S. Edwards, assistant; F. H. Dietz, A. R. Fauntleroy, and L. A. Sengteller, aids, (part of season.)	Resurvey of the bar and channels leading into Charleston harbor, S. C., and determination of the position of buoys and obstructions in the inner harbor. (See also Section X.)
	2	Topography and hydrography.	C. O. Boutelle, assistant; F. P. Webber, sub-assistant; W. W. Harding, L. L. Nicholson, C. P. Dillaway, and J. A. Guldin, aids.	Development of the new channels into Charleston entrance. Shore-line survey of Morris and Folly islands, S. C., and sounding of Light-house inlet and Folly river. Reconnaissance and pilot duty through the inland passage from Beaufort into St. Helena sound and in South Edisto river for vessels of the South Atlantic blockading squadron. Hydrography of the approaches to Wassaw sound, Ga. (See also Section VI.)
	3	Topography......	W. H. Dennis, sub-assistant; S. P. Holt, aid.	Plane-table survey of Bay Point and of Lands' End (Port Royal, S. C.) and shore-line survey of Morris and Folly islands. (See also Sections I and VI.)
SECTION VI. From St. Mary's river, Ga., to St. Joseph's bay, Fla., including the eastern and part of the western coast of Florida peninsula, and the Florida reefs and keys.	1	Topography......	W. H. Dennis, sub-assistant; S. P. Holt, aid.	Survey of the vicinity of Jacksonville and Pilatka, Fla., for military purposes. Reconnaissance of roads leading from Jacksonville to St. Augustine, to Picolata, and to Mayport Mills, and shore-line survey of the mouth of St. John's river. (See also Sections I and V.)
	2	Topography......	R. E. McMath..............	Special service at Fernandina and St. Augustine and compilation of maps for the use of the direct tax commissioners of Florida. (See also Sections I and III.)
	3	Hydrography......	C. O. Boutelle, assistant; Robert Platt, acting master, U. S. N., W. W. Harding, A. R. Fauntleroy, L. L. Nicholson, and C. P. Dillaway, aids.	Hydrographic resurvey of the bar of St. John's river, Fla., and of the channel upward to Mayport Mills. Buoys set and pilot duty rendered for vessels of the South Atlantic blockading squadron. (See also Section V.)
	4	Magnetic observations.	Samuel Walker..............	Observations continued at the Key West station.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTIONS VII, VIII AND IX.				
From St. Joseph's bay, Fla., westward to the Rio Grande, including part of the western coast of Florida, and the coast of Alabama, Mississippi, Louisiana, and Texas.	No. 1	Topography	Cleveland Rockwell, sub-assistant; R. H. Talcott, aid.	Topographical survey of the vicinity of Knoxville, Tenn., for military purposes.
	2	Topography	Cleveland Rockwell, sub-assistant.	Plane-table survey of Strawberry Plains, Tenn., for military purposes.
	3	Topography	F. W. Dorr, sub-assistant; J. W. Donn, sub-assistant.	Topographical survey of the vicinity of Nashville, Tenn., for military purposes. (See also Sections I and III.)
	4	Reconnaissance....	P. C. F. West, assistant.....	Military service and reconnaissances in connexion with the army of the Cumberland preceding and at the battle of Lookout mountain. (See also Sections I and III.)
	5	Topography	F. W. Dorr, sub-assistant: J. W. Donn, sub-assistant.	Plane-table survey of ground commanded by the defences of Chattanooga, Tenn., including Lookout mountain and valley, Raccoon mountain and Moccasin Point. (See also Sections I and III.)
	6	Reconnaissance....	Clarence Fendall, sub-assistant.	Reconnaissance for a road for military purposes across Raccoon mountain from Kelly's ferry to Whiteside, Tenn.
	7	Triangulation and topography.	C. H. Boyd, sub-assistant ...	Triangulation and plane-table survey of the battle-ground at Chickamauga, Ga., and its connexion with surveys in the vicinity of Chattanooga, Tenn.
	8	Triangulation, topography, and hydrography.	F. H. Gerdes, assistant; C. Fendall and T. C. Bowie, sub-assistants; J. B. Adamson, aid.	Shore-line survey and hydrographic reconnaissance of the Mississippi river between Rodney and Palmyra bend. Complete survey including the river at Grand Gulf, Miss. Completion of the plane-table survey of the defences of Vicksburg. Topography and hydrography of the Ohio river between Cairo and Mound City, Ill., and topographical surveys of Semmsport, Fort DeRussy and of the banks of Red river, La., between Alexandria and the falls.
	9	Reconnaissance and topography.	J. G. Oltmanns, assistant....	Military services reconnaissance and topographical surveys in connexion with the 19th army corps in Louisiana. (See also Section III.)
	10	Topography	Charles Hosmer, sub-assistant.	Topographical duty for the army of the Gulf at Aransas Pass, Pass Cavallo, and Matagorda entrances, Texas, at Madisonville and Morganza, La., and at Fort Adams, Miss. (See also Section I.)
SECTION X.				
From San Diego or the southern boundary of the United States on the Pacific to the forty-second parallel, including the coast of California.	1	Triangulation	W. E. Greenwell, assistant; Julius Kincheloe, sub-assistant.	Triangulation of the shore of Santa Barbara channel, Cal., extended from former limits towards Point Conception. Coast triangulation continued from Monterey bay northward and westward to Point Año Nuevo.
	2	Triangulation	J. S. Lawson, assistant; C. B. Boutelle, aid, (part of season.)	Triangulation of Suisun bay, Cal., commenced and extended from eastward. (See also Section XI.)
	3	Hydrography......	Aug. F. Rodgers, assistant; Alexander Chase, aid.	In-shore hydrography completed between Point San Pedro and Tunitas creek, including Half Moon bay, Cal. Hydrographic resurvey of Mare Island strait.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION X—Continued.	No. 4	Hydrography	W. S. Edwards, assistant; C. B. Boutelle, aid, (part of season.)	Resurvey of Mare Island strait and examination of San Pablo bay, between San Pablo Point and Pinole Point; soundings in Suisun bay and inshore hydrography between Point Piedra and Point Año Nueva. (See also Section V.)
	5	Tidal observations.	Captain G. H. Elliot, U. S. engineers, in charge; A. Cassidy and H. E. Uhrlandt.	Observations continued with self-registering gauges at the tidal stations near San Diego and San Francisco.
SECTION XI.				
From the 42d parallel of latitude to the northwestern boundary of the United States, including the coast of the State of Oregon and the coast of Washington Territory.	1	Triangulation and shore line survey.	J. S. Lawson, assistant; C. B. Boutelle, aid.	Triangulation of Koos bay, Oregon, completed and shore-line traced. (See also Section X.)
	2	Tidal observations	Louis Wilson	Series continued with the self-registering tide-gauge at Astoria, Oregon.

APPENDIX No. 2.

Information furnished from the Coast Survey office by tracings from original sheets, &c., in reply to special calls, during the year 1863–'64.

Date.		Names.	Data furnished.
1863.			
Nov.	2	C. H. Haswell, esq	Table of latitudes and longitudes of principal cities of the United States, determined by the United Sates Coast Survey.
	9	E. P. Hannaford, esq	Table of prominent geographical positions in Maine.
	13	Lt. Col. B. S. Alexander, corps of engineers	Hydrographic and topographical survey of part of the Narrows, N. Y.
	24	Major Gen. John J. Peck, U. S. A	Topographical survey of Smith's island, entrance to Cape Fear river, N. C.
	25	U. S. tax commission for South Carolina	Connected topographical survey from St. Helena sound to the Savannah river, including Port Royal island.
Dec.	5	Prof. Powalky, Berlin, Prussia	Latitude and longitude of American stations occupied for observing the last transit of Venus in 1769.
	16	Hon. L. M. Sweat, Maine	Topographical survey of Portland harbor, with colored proof of same.
	22	Capt. T. L. Casey, corps of engineers	Table of magnetic declinations in Maine.
	24	Rear-Admiral Lessoffsky, Russian navy	Hydrographic survey of Smith's Island shoal, entrance to Chesapeake bay.
	28	Major Charles E. Blunt, corps of engineers	Topographical survey of Eastern Point, entrance to Gloucester harbor, Mass.
1864.			
January	4	War Department	Topographical survey of Pass Cavallo and Aransas pass, Texas, showing rebel fortifications and rifle pits.
	4	Navy Department	Topographical survey of Pass Cavallo and Aransas pass, Texas, showing rebel fortifications and rifle pits.
	4	Engineer department	Topographical survey of Pass Cavallo and Aransas pass, Texas, showing rebel fortifications and rifle pits.
	7	Post Office Department	Topographical survey of part of Accomac county, with shore-line of sea-coast and eastern shore of Chesapeake bay.

APPENDIX No. 2—Continued.

Date.		Names.	Data furnished.
1864.			
January	23	Navy Department	Special survey for underwriters of ship Aquila, sunk at Hathaway's wharf, San Francisco, with plates for monitor Camanche aboard; also view of same.
February	4	Major Charles E. Blunt, corps of engineers	Topographical survey of extremity of Cape Cod, Mass.
	22	U. S. commission on Sandy Hook	Hydrographic resurvey of Sandy Hook, N. J.
March	8	Engineer department	Topographical survey western entrance to Narragansett bay, R. I.
	9	Admiral S. P. Lee, U. S. N	Compiled map of Beaufort and vicinity, N. C.
	16	Light-house Board	Topographical survey west side of the Thames river, vicinity of New London, Conn.
	18	William Keeler, constructing engineer	Topographical survey west side of the Thames river, vicinity of New London, Conn.
	18	Major Gen. A. E. Burnside, U. S. A	Compiled map State of North Carolina.
	30	Hon. James K. Moorhead, Pa	Topographical survey of the Thames river, vicinity of New London, Conn.
April	15	Major Gen. W. F. Smith, U. S. A	Topographical survey of City Point, Va.
	19	Hon. Samuel J. Randall, Pa	Topographical survey of League island and vicinity, Delaware river.
	21	Major Gen. W. F. Smith, U. S. A	Topographical survey of the James river from City Point to Falling creek.
	21	Col. R. Delafield, corps of engineers	Comparative map of Sandy Hook, from surveys of 1856 and 1863.
	29	Major Gen. W. F. Smith, U. S. A	Complete topographical survey of the Appomattox river, Va.
	29	do	Part of the topographical survey of the James river, Va., from Warwick bar to Richmond.
	29	Admiral S. P. Lee, U. S. N	Hydrographic survey of Roanoke, Eastmost and Middle rivers, N. C.
	29	do	Topographical survey of Roanoke, Eastmost and Middle rivers, N. C.
May	21	Lt. Comd. S. L. Phelps, U. S. N	Tracings of sketches of part of the Red river, La.
June	11	Northwest boundary commission	Topographical survey of Strawberry bay, W. T.
	14	Gov. John A. Andrew, Mass	Topographical survey of Boston lower bay, Mass.
	28	J. D. Jones, esq	Hydrographic and topographical survey of Cold Spring harbor, Long Island, N. Y.
July	2	Brig. Gen. C. Grover, U. S. A	Sketch of Red river and vicinity, from its mouth to Grand Ecore, La.
	6	Brig. Gen. J. G. Barnard, chief engineer armies in the field.	Hydrographic survey of Appomattox river, Va.
	6	Admiral S. P. Lee, U. S. N	Combined map of Croatan sound, N. C.
	13	Brig. Gen. G. Weitzel, U. S. A	Topographical survey of Appomattox river, Va.
	26	Engineer bureau	Topographical survey beyond the northeast and southeast boundaries of the District of Columbia.
	27	Henry A. Webster, esq., Indian agent, Washington Territory.	Sketch of Gray's harbor, W. T.
	29	Admiral S. P. Lee, U. S. N	Hydrographic survey of Trent's reach, James river, Va.
August	1	A. Bowers, esq., California	Topographical survey of Petaluma creek, Cal.
	3	Col. Henry Brewerton, U. S. A	Topographical survey west side of Baltimore, Md.
	8	do	Topographical survey northwest side of Baltimore, Md.
	10	Brig. Gen. A. P. Howe, U. S. A	Combined duplicate drawings of the Potomac river from Fort Washington to Alexandria.
	12	Lt. Col. B. S. Alexander, corps of engineers	Hydrographic survey off Fort Foote, Potomac river.
	12	W. J. Newman, Light-house engineer	Topographical survey of Blakistone island, Potomac river.
	12	Major J. C. Woodruff, corps of engineers	Topographical survey northeast of District of Columbia, from Bladensburg to Leesboro'.
	16	Brig. Gen. J. A. Haskin, artillery defences of Washington.	Combined map of Potomac river from Fort Washington to Alexandria.

APPENDIX No. 2—Continued.

Date.		Names.	Data furnished.
1864.			
August	16	Major Gen. J. G. Foster, U. S. A.	Proof of coast map No. 53, scale $\frac{1}{80000}$, with details of topography colored.
	16	Major Nathaniel Michler, corps of engineers	Topographical survey of the Appomattox river, Va.
	18	Hon. Charles O'Neill, Pennsylvania	Topographical survey mouth of the Housatonic river, Conn.
	20	Engineer bureau	Topographical survey of Point Lookout, Md.
	30	Brig. Gen. A. P. Howe, U. S. A.	Topographical survey of northeast approaches to Washington city.
Sept.	10	Brig. Gen. G. Granger, U. S. A.	Topographical survey of part of Mobile bay, Ala.
	17	Navy Department	Topographical survey of coast of North Carolina, from Masonboro' inlet to Lockwood's Folly inlet.
	22	Brig. Gen. A. P. Howe, U. S. A.	Shore-line of New York bay with line of deepest water.
October	1	Navy Department	Topographical survey of coast of North Carolina, from Masonboro' inlet to Lockwood's Folly inlet.
	4	Brig. Gen. G. Weitzel, U. S. A.	Copy of a map of Cape Fear river, from its entrance to Wilmington, and the adjoining coast of North Carolina.
	8	Comd. J. P. Bankhead, U. S. N.	Topographical survey of Hutchinson island, St. Helena sound, S. C.
	17	Admiral C. K. Stribling, U. S. N.	Shore-line and hydrography of main entrance to Charlotte harbor, Fla.

APPENDIX No. 3.

Statistics of field and office work of the United States Coast Survey during the years—

	Previous to 1844.	From 1844 to 1848.	From 1849 to 1853.	From 1854 to 1858.	1859.	1860.	1861.	1862.	1863.	Tota..
Reconnaissance—										
Area, in square miles	9, 642	13, 599	20, 363	9, 918	1, 782	6, 050	585	716	134	53, 147
Parties, number of, in each year	4	5	5	7	3	1	1	4	5	
Base lines—										
Primary, number of	1	4	2	3						10
Secondary, number of	2	3	19	23	5	2	1	2	1	58
Length of, in miles	19¼	38	49	50	6	1	1	1	1	166
Triangulation—										
Area, in square miles	9, 076	8, 641	13, 445	12, 896	3, 724	4, 773	1, 632	1, 514	567	56, 268
Extent of general coast, in miles	570	738	1, 058	1, 389	358	232	173	152		4, 670
Extent of shore-line, in miles, including bays, sounds, islands, and rivers	1, 588	3, 498	5, 143	7, 761	2, 092	1, 617	1, 200	1, 061		23, 960
Horizontal angle stations occupied	750	615	992	1, 927	344	322	159	168	181	5, 458
Geographical positions determined	1, 183	1, 088	1, 712	3, 592	794	681	402	452	371	9, 904
Vertical angle stations occupied	15	18	74	111	17	17	10	18	63	343
Elevations determined, number of	44	110	209	174	31	44	11	26	78	727
Parties, number of, in each year	4	8	14	19	21	21	14	12	12	
Astronomical operations—										
Stations occupied for azimuth	9	18	29	14	7	5	2	2		86
Stations occupied for latitude	9	26	55	24	5	6	2	2		129
Stations occupied for longitude	1	9	56	10	1	7	2			85
Permanent longitude stations		6	20	10	1	1	1	1	1	41
Special longitude stations for occultations, &c				63	24	24				111
Parties, number of, in each year	1	3	5	5	5	6	2	2	1	
Magnetic stations occupied, number of		86	51	49	18	19	6	6	8	243
Parties, number of, in each year		3	3	4	4	7	4	2	4	
Topography—										
Area surveyed, square miles	6, 131	2, 514	3, 072	3, 523	657	592	577	424	171	17, 661
Length of general coast, in miles	414	699	975	1, 116	224	320	190	259	16	4, 213
Length of shore-line, in miles, including rivers, creeks, and ponds	7, 667	5, 586	8, 863	13, 862	2, 669	2, 052	1, 737	1, 240	626	44, 302
Length of roads, in miles	11, 734	4, 788	2, 749	4, 660	482	260	1, 232	1, 249	537	27, 691
Parties, number of, in each year	6	7	13	18	22	23	17	20		
Hydrography—										
Parties, number of, in each year	2	6	10	11	9	9	9	13		
Number of miles run while sounding	29, 214	20, 094	39, 468	58, 822	9, 426	9, 438	2, 434	5, 916	6, 397	181, 209
Area sounded out, square miles	9, 601	5, 068	11, 431	13, 617	4, 310	1, 651	225	611	725	47, 239
Miles run additional, of outside or deep-sea soundings	1, 800	3, 470	5, 497	14, 524	2, 353	2, 375				30, 019
Soundings, number of	808, 147	349, 807	1, 495, 954	2, 148, 584	398, 053	373, 251	224, 978	385, 405	269, 700	7, 053, 879
Soundings in Gulf Stream for temperature		1, 331	1, 053	1, 217	235	236				4, 072
Tidal stations, permanent		9	21	40	10	11	7	7	7	

APPENDIX No. 3—Continued.

	Previous to 1844.	From 1844 to 1848.	From 1849 to 1853.	From 1854 to 1858.	1859.	1860.	1861.	1862.	1863.	Total.
Hydrography—										
Tidal stations occupied temporarily	127	148	281	370	32	50	27	34	14	1,083
Tidal parties, number of, in each year	2	6	11	13	10	12	7	9	6	....
Current stations occupied	....	223	226	381	38	84	44	7	9	1,012
Current parties, number of, in each year	....	4	6	4	2	1	2	1	1	....
Specimens of bottom, number of	1,029	4,134	1,302	1,626	164	188	11	....	....	8,454
Records—										
Triangulation, originals, number of volumes	97	101	208	393	94	120	82	57	52	1,204
Astronomical observations, originals, number of volumes	17	69	220	233	27	35	13	17	3	634
Magnetical observations, originals, number of volumes	4	20	26	64	9	13	17	6	18	177
Duplicates of the above, number of volumes	27	183	236	632	77	111	103	53	35	1,457
Computations, number of volumes	78	112	294	483	88	115	66	24	46	1,306
Hydrographic soundings and angles, originals, volumes	188	408	906	1,236	306	194	129	86	171	3,624
Hydrographic soundings and angles, duplicates, volumes	28	33	82	101	19	10	4	2	6	285
Tidal and current observations, originals, volumes	127	205	531	693	75	64	39	27	16	1,777
Tidal and current observations, duplicates, volumes	....	206	773	407	57	54	15	16	13	1,541
Sheets from self-registering tide-gauges, number of	....	....	98	549	140	180	118	75	77	1,246
Tidal reductions, number of volumes	....	410	139	378	52	60	46	28	28	1,141
Total number of volumes of records	566	1,717	3,415	4,620	804	775	511	312	388	13,138
Maps and charts—										
Topographical maps, originals	168	104	194	273	45	47	33	44	23	931
Hydrographic charts, originals	142	74	195	263	41	37	16	32	35	835
Reductions from original sheets, number of	15	70	149	177	92	23	21	19	19	585
Total number of manuscript maps and charts	325	248	538	713	178	107	70	95	....	2,274
Number of sketches made in field and office	311	166	533	617	353	108	62	65	71	2,286
Engraving and printing—										
Engraved plates of finished charts, number of	5	19	23	25	8	8	9	6	6	109
Engraved plates of preliminary charts, sketches and diagrams for the Coast Survey reports, number of	....	16	113	215	21	17	14	8	12	416
Electrotype plates made in each year	....	8	117	370	87	58	43	43	28	754
Finished charts published in each year	....	24	22	24	6	7	7	6	6	....
Preliminary charts and hydrographic sketches published	....	8	103	169	15	15	31	34	15	....
Printed sheets of maps and charts distributed	....	6,320	21,664	42,801	10,486	4,092	13,094	36,273	25,659	160,389
Printed sheets of *ditto* deposited with sale agents	....	12,563	21,030	11,072	3,584	2,145	733	4,448	3,615	59,190
Library—Number of volumes	....	635	1,462	1,016	174	159	163	91	136	3,856
Instruments—Cost of	....	....	$26,712	$19,138	$1,852	$1,729	$2,522	$894 93	$1,832 87	$54,680

GENERAL NOTE.

Parties.—An average number is given for the years previous to 1844. A party operating in more than one section during the year is counted but once.

Triangulation.—The extent of general coast is measured in general outline, including Delaware and Chesapeake, as well as all open bays, but omitting the minor indentations of the sea-coast. The extent of shore-line is also measured in general outline, and includes such rivers only as have been triangulated.

Topography.—The length of general coast is measured similarly to that under triangulation; but the shore-line under topography represents the whole water-line surveyed, including all the minor indentations, as represented on the plane-table sheets.

Records.—The *total* number of volumes of records given in the table is *greater than* the number *now on hand*, owing to the binding up of separate volumes.

Engraved plates.—Progress sketches (averaging fourteen yearly) are not counted.

Library.—The number of volumes purchased and donated up to 1849 was 655.

It is to be remarked that the numbers appearing in the column of this table for the year immediately preceding that of its compilation are, in some cases, *subject to be changed, more or less*, in the succeeding report, owing to data not being, at the time of compilation, fully turned into the office from the distant parties in the field.

APPENDIX No. 4.

GENERAL LIST OF COAST SURVEY DISCOVERIES AND DEVELOPMENTS TO 1863, INCLUSIVE.

1. Examination of the channels leading into Carver's harbor, (Penobscot bay,) with reference to the positions of rocks and shoals dangerous to navigation, 1863.

2. A dangerous ledge determined in position, with only eleven feet at mean low water, two miles west of the north end of Metinic island, mouth of Penobscot bay, 1863.

3. A ledge with four fathoms of water on it, discovered S.SW. ¼ W., (true,) and a mile and a quarter from Pemaquid light-house, coast of Maine, 1860.

4. Numerous dangerous reefs and ledges developed at the entrance and in the approaches of Damariscotta river, Maine, 1860.

5. Two rocks, one with three and a quarter fathoms, the other with only ten feet of water, and a ledge with three and a half fathoms, found in the channel of Booth bay, Maine, 1860.

6. Determination in position and depth of ten rocks near the approaches of Portland harbor, and of a spot with only fourteen feet water on Bulwark shoal; on Vapor Rock, twenty feet; on Witch Rock, twenty-four; on Corwin Rock, twenty-four and a half; on Mitchel Rock, thirty-one; on Willard Rock, thirty-one and a half; on Bache Rock, thirty-two feet; on Round Rock, thirty feet; on Old Anthony or Vapor Rock, twenty feet; on the Western Hue-and-Cry, twenty-seven and a half feet; on West Cod ledge, thirty-four feet; and on East Cod ledge, forty-nine feet; 1863.

7. Jeffrey's bank and Jeffrey's ledge, off the coast of Maine, thoroughly sounded out, 1860.

8. Only eighteen feet at mean low water found on the rock one mile to the southward of Seguin island, coast of Maine, 1859.

9. Temple's ledge, near Cape Small Point, Maine, 1857.

10. True position of the Hussey Rock, in Casco bay, determined, correcting the erroneous one assigned on previous charts, 1859.

11. Determination of the position of a sunken rock on which the steamer Daniel Webster struck, in Casco bay, on the evening of the 13th of October, 1856.

12. Determination of the dimensions of Alden's Rock, near Cape Elizabeth, Maine, 1854.

13. Determination of the position of the "Hue-and-Cry," the "Old Proprietor," and other dangers off Cape Elizabeth, Maine, 1859.

14. Huzzy's Rock, south of Fletcher's Neck, Maine, determined in position, 1859.

15. Development of a four-fathom bank off Cape Porpoise, Maine, 1859.

16. Fishing ledge, off Kennebunk, Maine, thoroughly sounded, 1859.

17. A rock one mile to the southward and westward of Boon island, with seventeen feet water; the sea breaks on it in heavy weather, 1858.

18. Development of a rock off Ogunquit, bare at low tides, and very little known, 1859.

19. Development of Boon Island ledge, coast of Maine, 1858.

20. A rock off Cape Neddick, Maine, determined in position, 1858.

21. A detached rock, two-thirds of a mile northward and eastward of York ledge, Maine, 1858.

22. Determination of the position of a rock more than a mile off the mouth of York river, Maine, bare at low tides and dangerous to coasters, 1858.

23. Development of Duck Island ledge, 1858.

24. A fishing bank sounded out off Wood island, coast of Maine, 1859.

25. A very dangerous rock, with only six and a half feet water, off the entrance to Portsmouth harbor, New Hampshire, about four nautical miles eastward from the Whale's Back light, 1858.

26. A rock with twelve feet at mean low water, about four miles and a third eastward of the Whale's Back, 1858.

27. Determination of the positions of four points of rock in Sandy bay, (Cape Ann,) Massachusetts, 1861.

28. A rock (not on any chart) in the inner harbor of Gloucester, Massachusetts, discovered in 1853.

29. Determination of rocks off Marblehead and Nahant, 1855.

30. Determination of the position of White Rock ledge, at the entrance of Saugus river, Massachusetts, 1860.

31. A bank ninety miles eastward of Boston, with about thirty-six fathoms of water, probably a knoll connected with Cashe's ledge, but with deep water between it and the ledge, 1853.

32. Boston harbor, Broad Sound channel thoroughly surveyed and marks recommended, 1848.

33. Several rocks in the fair channel-way in Boston harbor entrance, 1854.

34. An extension of the sand-pit to the southward of Sunken ledge, Boston harbor, since the survey of 1847; 1858.

35. Discovery of a rock with only seventeen feet of water at mean low tide in the Narrows of Boston harbor, 1860.

36. Special investigation of the currents of Boston harbor, 1860 and 1861.

37. A bank (Stellwagen's bank) with ten and a half to fourteen and a half fathoms of water on it, at the entrance to Massachusetts bay, and serving as an important mark for approaching Boston and other harbors, 1854.

38. Extension of Stellwagen's bank to the southward and eastward some sixteen or seventeen square miles, enclosed by the twenty-fathom curve, 1855.

39. Changes in the vicinity of East harbor, (Cape Cod,) 1857.

40. Special tidal and current observations at the mouth of Scusset river, (Cape Cod bay,) 1860.

41. A dangerous sunken ledge (Davis's ledge) to the eastward and in the neighborhood of Minot's ledge, 1854.

42. Development of a reef extending between Minot's and Scituate light, 1856.

43. A sunken rock, with only six feet on it at low water, off Webster's Flag-staff, Massachusetts bay, 1856.

44. A dangerous rock near Saquish Head, entrance to Plymouth harbor, 1856.

45. Three rocks determined in position, partly bare at low water, off Manomet Point, Massachusetts bay, 1856.

46. Determination of a very dangerous rock off Indian Hill, and four miles southward of Manomet Point, Massachusetts bay, with as little as six feet water on it, 1856.

47. The currents of Cap Cod bay observed with reference to their physical effects on the shores, 1861.

48. Determination of the position of a small rock with less than four feet at mean low water, near the channel and in the vicinity of Great Rock, Hyannis harbor, Massachusetts, 1859.

49. Probable connexion of George's bank and the deep-sea banks north and east of Nantucket, 1855.

50. The decrease of depth, with general permanence of form of George's bank, off the coast of Massachusetts, 1857.

51. A shoal spot near Little George's bank, 1857.

52. Non-existence determined of "Clark's bank" and "Crab ledge," laid down on certain charts as distinct from an immense shoal ground off Cape Cod peninsula, 1856.

53. Nantucket shoals; Davis's new South shoals, six miles South of the old Nantucket South shoals in the track of all vessels going between New York and Europe, or running along the coast from the eastern to the southern States, or to South America; discovered in 1846.

54. Two new shoals north and east of Nantucket; discovered in 1847.

55. Six new shoals near Nantucket, the outermost fourteen and a half miles from land, and with only ten feet water; discovered in 1848.

56. McBlair's shoals off Nantucket; discovered in 1849.

57. The tidal currents of Nantucket shoals and the approaches, 1854.

58. Davis's bank, Nantucket shoals; discovered in 1848, and survey finished in 1851.

59. Fishing Rip, a large shoal extending north and south, about ten miles to the eastward of Davis's bank, and thirty miles from Nantucket, with four and a half fathoms; surveyed in 1852.

60. A ridge connecting Davis's new South shoal and Davis's bank; found in 1853.

61. A small bank or knoll with but five fathoms on it, about five miles east of Great Rip, with twelve fathoms between it and Davis's bank and Fishing Rip, the water gradually deepening outside of it to the northward and eastward beyond the limits of the series of shoals, 1853.

62. Discovery of a shoal lying N.NE., over six miles long, and twenty-four miles southeast of Davis's South shoal, with ten to ten and a half fathoms of water, 1860.

63. Discovery of three small banks off the Nantucket shoals in the vicinity of Phelps's bank, and further development of the extent of that shoal ground, 1861.

64. Discovery of Edwards's shoal, one mile and seven-eighths southward of Nantucket light-boat, 1855.

65. Examination of the interference tides of Nantucket and Martha's Vineyard sounds, 1855.

66. The study of the tidal currents of the Vineyard and Nantucket sounds, 1857.

67. Contraction of the inlet at the north end of Monomoy island, and opening of a new entrance to Chatham harbor, 1853.

68. Muskeget channel, surveyed by Lieutenant C. H. Davis in 1848, and Lieutenant C. H. McBlair in 1850.

69. Discovery of two shoal spots, with twelve and thirteen feet water, eastward from Great and Little Round shoals, Nantucket sound, 1856.

70. Determination of two shoal spots near the northern extremity of Davis's bank, with fourteen and eighteen feet water, 1856.

71. Further development of Edward's shoal, three-fourths of a mile from the southern Cross Rip, Nantucket sound, 1856.

72. Shoal sand ridges discovered northward of Great Point light, Nantucket sound, 1856.

73. Important changes in geographical feature at the southeastern end of Martha's Vineyard, Muskeget channel, 1856.

74. Numerous rocks in Martha's Vineyard sound, Long Island sound, and the various bays and harbors connected with them.

75. Several dangerous rocks and ledges developed in the approaches of Sippican harbor, (Buzzard's bay,) and others inside of the harbor, 1863.

76. Two rocks discovered in the approaches to Newport harbor, R. I. One of these has fourteen and a quarter feet of water on it at mean low tide; the other has seventeen feet at low water. Ten other rocks, before known, were determined in position, 1862.

77. Luddington Rocks determined in position, about ten yards apart, a mile and a half (nautical) southwest by compass from New Haven light, 1858.

78. Development of a ledge (Great Eastern ledge) off Montauk Point, having at one point only twenty-four feet at mean low water, and at another twenty-seven feet, 1863.

79. The tidal currents of Long Island sound, 1854.

80. The tidal currents of Hell Gate, 1857.

81. Least water on the Hell Gate Rocks determined by dragging, 1857.

82. Tidal currents in East river, New York, and surface and sub-currents investigated in New York harbor, the lower bay, and on the bar, 1858.

83. The currents of the great bay between Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, 1855.

84. Gedney's channel, in New York bay, having two feet more water than the old channels. Had the true depth of this channel been known in 1778, (then probably existing, as seen by comparing old and new charts,) the French fleet, under Count D'Estaing, would have passed into the bay and taken the assembled British vessels, 1845.

85. The changes in New York harbor, near New York city, between 1845 and 1858.

86. Increase of depth in Buttermilk channel, ascertained and made known in 1848 by survey of Lieutenant D. D. Porter, United States navy.

87. The existence of a seventeen-foot spot on the shoal off the battery, New York harbor, the extension of the shoal towards the channel, and the shoaling of the water generally between the shoal and shore, 1859.

88. Shoal in the main ship channel of New York harbor, 1855.

89. The existence and character of sub-currents ascertained as bearing on the physical conditions of New York harbor, 1859.

90. The tides of Hudson river, 1856.

91. Sandy Hook: its remarkable increase traced from the surveys of the topographical engineers and others, and by several successive special surveys made betwen 1844 and 1863.

92. Development, by soundings, of a ridge lying sixteen miles off Barnegat, N. J., with eleven to thirteen fathoms of water, and sixteen fathoms between it and the coast, 1861.

93. The alteration of shore-line and sea encroachment near Absecom light-house, coast of New Jersey, 1863.

94. Special examination made and changes noted in the vicinity of the Five-fathom bank, off Cape May, 1861.

95. Development of hydrographic changes at the Delaware breakwater, 1863.

96. Delaware bay; Blake's channel at the entrance, discovered in 1844; open when the eastern channel is closed by ice. This discovery has served to develop strikingly the resources of that portion of Delaware.

97. Blunt's channel, in Delaware bay.

98. Changes in the Delaware, near the Pea Patch, 1847.

99. Hydrographic changes developed in the Delaware river, at the Bulk Head shoal, near Fort Delaware, at the bar off Fort Mifflin, and opposite to Philadelphia, 1861.

100. Special survey of part of League island, Delaware river, and comparison of changes with previous surveys, 1863.

101. Examination of soundings eastward of Winter Quarter shoal to determine the alleged existence of a second shoal, 1863.

102. The true extent and position of the dangerous shoals near Chincoteague inlet, Virginia, 1852.

103. Metomkin inlet, Virginia, shoaling from eleven to eight feet in the channel during 1852.

104. The shifting of the bar of Metomkin inlet, Virginia, and changes of shore-line, but without alteration of depth on the bar, 1862.

105. Two channels into Wachapreague inlet, Virginia—one from the northward, and the other from the eastward—both with seven feet water at low tide, 1852.

106. A shoal half a mile in extent, not put down on any chart, five and a half miles east from the north end of Paramore's island, Virginia. It has but four fathoms water on it, and nine fathoms around it, 1852.

107. Great Machipongo inlet, Virginia. Found to have a fine wide channel, with eleven feet water on the bar at low ebb and fourteen at high tide. Good anchorage inside, from two to eight fathoms. The best harbor between the Chesapeake and Delaware entrances; 1852.

108. Two shoals near the entrance to the Chesapeake—one four and three-quarters nautical miles SE. by E. from Smith's Island light-house, with seventeen feet water upon it; the other, E. by S., nearly seven and three-quarters miles from the same light, with nineteen and a half feet upon it; 1853.

109. Only three feet water upon the "Inner Middle," the shoal part of the Middle Ground, west of the "north channel," at the Chesapeake entrance, 1852.

110. A twenty-five-fathom hole, two and a half miles W.SW. from Tazewell triangulation point, eastern shore of the Chesapeake. All other charts give not more than sixteen fathoms in this vicinity.

111. A shoal at the mouth of the Great and Little Choptank, in Chesapeake bay, 1848.

112. The sounding and measurement of the bars in Rappahannock river, 1855.

113. The general permanence of the Bodkin channel and shoals in its vicinity, at the entrance of the Patapsco river, between 1844 and 1854.

114. Changes developed in the shore-lines at the entrance of Little Annemessex river, Chesapeake bay, 1859.

115. A shoal (New Point shoal) in Chesapeake bay, with sixteen feet water on it, southeast from New Point Comfort light-house, off Mobjack bay, 1854.

116. Re-examination of York spit, Chesapeake bay, and least water determined, (nine feet,) 1855.

117. York river, Va., as a harbor, 1857.

118. Development of the best line of water for crossing the Kettlebottom shoals, Potomac river, there being no well-defined channel, 1862.

119. Changes in depth and outline at Oregon inlet, N. C., 1862

120. A reconnaissance of the Wimble shoals, near Nag's Head, coast of North Carolina, 1854.

121. Submarine range of hills beyond the Gulf Stream tracked from Cape Florida to Cape Lookout, 1855.

122. Deep water found on Diamond shoal, and a dangerous nine-feet shoal off Cape Hatteras, 1850.

123. A new channel, with fourteen feet water, into Hatteras inlet, formed during the year 1852, which is better and straighter than the old channel.

124. Changes at Hatteras and Ocracoke inlets, 1857.

125. Extent of the sea encroachment at Cape Hatteras, and changes found near Hatteras inlet, N. C., 1860 and 1861.

126. Special examination of the tides and currents, with reference to the hydrographic and shore-line changes at Hatteras inlet, N. C., 1862.

127. A shoal found with only fourteen feet of water, S. by E. $\frac{1}{2}$ E., and distant ten and a half miles from Cape Lookout light-house, 1863.

128. The general permanence in depth on the bar of Beaufort, N. C., with the changes of position of the channel, 1854.

129. Changes on the bar of Beaufort, N. C., 1857.

130. Development of the alteration in outline and depth at the entrance of Beaufort harbor, N. C., 1862.

131. The well-ascertained influence of prevailing winds in the movement of the bars at Cape Fear and New Inlet entrances, and the gradual shoaling of the main bar; the latter fact being of great importance to the extensive commerce seeking that harbor, 1853.

132. Changes in the main Western and New Inlet channels in Cape Fear, 1855.

133. Frying Pan shoals, off Cape Fear, N. C.; a channel of two and a half fathoms upwards of a mile wide, distant eleven nautical miles from Bald Head light-house across the Frying Pan shoals. A channel extending from three to four miles from the point of Cape Fear to eight or eight and a half miles from it, with sufficient water at low tide to allow vessels drawing from nine to ten feet to cross safely. A channel at the distance of fourteen nautical miles from Bald Head light-house, one mile wide, with three and a half to seven fathoms water on it. The Frying Pan shoals extend twenty nautical miles from Bald Head light-house, and sixteen, seventeen, and eighteen feet water is found seventeen and eighteen nautical miles out from the light, 1851.

134. Shoaling of Cape Fear River bar thoroughly examined for purposes of improvement, 1852.

135. Changes of shore-line and hydrography determined at the Cape Fear entrances, N. C., 1858.

136. Changes of the Cape Fear bars and channels, 1857.

137. Changes at the entrance of Winyah bay and Georgetown harbor, and the washing away of Lighthouse Point at the same entrance, 1853.

138. Less water found off Cape Roman, by preliminary examination, than has been heretofore assigned, 1859.

139. Re-examination, by soundings, of the Rattlesnake shoal, S. C., 1862.

140. Maffitt's new channel, Charleston harbor, with the same depth of water as the ship channel, 1850.

141. The changes in Maffitt's channel, Charleston harbor, S. C., from 1852 to 1857.

142. Increase of depth developed in Maffitt's channel, Charleston harbor, S. C., 1858.

143. Changes in the main ship channel, Charleston harbor, 1851.

144. Changes in the channels at the entrance of Charleston harbor, 1852.

145. The remarkable discovery of continuous deep-sea soundings off Charleston, and of soundings in the depth of between four and five hundred fathoms beyond the Gulf Stream, 1853.

146. Stono entrance, S. C., sounded, and channel found half a mile to westward of its former position, with slight increase of depth, 1862.

147. Development of the changes affecting the entrance to North Edisto river, S. C., 1856.

148. The shoaling of North Edisto entrance from its former depth, to nine feet of water.

149. St. Helena entrance, S. C., examined, and a new channel from the eastward found, giving sixteen feet at mean low water, 1862.

150. Greater depth found through the channel of Coosaw river, S. C., (inland passage,) than has been hitherto supposed to exist, 1860.

151. Discovery of a new channel between Martin's Industry (shoal) and the southeast breakers, Port Royal entrance, S. C., 1856.

152. The south channel of Port Royal sound developed, and nineteen and a half feet found to be the least depth of water, 1862.

153. The channel of the inland passage thoroughly sounded, leading from Port Royal sound to Tybee roads, through Skull creek and Calibogue sound, 1862.

154. Discovery of cold water at the bottom of the ocean below the Gulf Stream, along the coast of North and South Carolina, Georgia, and Florida, 1853.

155. The discovery of the cold wall, alternate warm and cold bands, and various other features of the Gulf Stream, especially such as concern its surface and deep-sea temperatures, and its distribution relative to the shore and bottom of the ocean.

156. Various facts relative to the distribution of minute shells on the ocean bottom, of probable use to navigators for recognizing their positions.

157. Changes in shore-line and in depth observed in Ossabaw sound, Ga., 1860.

158. A new channel developed leading into Sapelo sound, Ga., three-quarters of a mile southward, and better than the one in use, 1860.

159. Examination of Doboy, St. Simon's, and Cumberland entrances, 1855.

160. The bar and entrance of St. Simon's sound, Ga., examined, showing no material change of depth within the past two years, 1862.

161. The shifting to southward and shoaling by several feet of the channel into Fernandina harbor, Fla., having now only eleven feet at mean low water, 1862.

162. A shoal inside of the entrance to Amelia river, Fla., 1857.

163. Hetzel shoal, off Cape Cañaveral, Fla., 1850.

164. A shoal spot found off the coast of Florida, ten miles from land and fifteen miles NE. of Indian River inlet, 1860.

165. Temperature of 34° beneath the Gulf Stream, thirty-five miles east of Cape Florida, at a depth of three hundred and seventy fathoms, 1855.

166. Further explorations and investigations in developing the character of the Gulf Stream in the Florida channel, 1859 and 1860.

167. A harbor of refuge (Turtle harbor) to the northward and westward of Carysfort light-house, Florida reef, with a depth of water of twenty-six feet at the entrance, 1854.

168. A new passage, with three fathoms water, across the Florida reef, to Legaré harbor, under Triumph reef, (latitude 25° 30′ N., longitude 80° 03′ W.,) which, if properly buoyed, will be valuable as a harbor of refuge, 1852.

169. A safe rule for crossing the Florida reef near Indian key, 1854

170. Tennessee shoal, Florida reef, developed, giving only twelve feet of water on its outer patch, 1860.

171. The position of a sunken wreck determined and marked, lying off Grassy key, Florida reef, and near the track of vessels, 1860.

172. A new channel into Key West harbor, 1850.

173. Co-tidal lines for the Atlantic coast of the United States, 1854.

174. Rules for navigators in regard to the tidal currents of the coast, 1857.

175. Isaac shoal, near Rebecca shoal, Florida reef; not laid down on any chart; 1852.

176. Channel No. 4, a northeast entrance into Cedar Keys bay, 1852.

177. Directions for entering the harbor from Crystal River offing, west coast of Florida peninsula, 1856.

178. A new channel discovered, leading into St. George's sound, (Apalachicola, Fla.,) at the east end of Dog island, and anchorage connected with it, 1858.

179. Shoals near the east and west passes of St. George's sound, (Apalachicola, Fla.,) and a new channel found between St. George's and St. Vincent's islands, 1858.

180. Indications noticed of a deeper and better channel forming to lead to the East Pass anchorage, St. George's sound, Fla., 1860.

181. Changes in the depth of water observed by comparison of soundings at Perdido entrance, 1860.

182. Mobile Bay Entrance bar; in 1832 only seventeen feet at low water could be carried over it; in 1841 it had nineteen, and in 1847 it had twenty feet and three quarters, as shown by successive surveys; 1847.

183. The diminution, almost closing, of the passage between Dauphine and Pelican islands, at the entrance of Mobile bay, 1853.

184. The currents of Mobile bay specially investigated, 1860.

185. Horn Island channel, Mississippi sound, 1852.

186. The removal of the east spit of Petit Bois island in the hurricane of 1852, opening a new communication between the Gulf and Mississippi sound, and the rendering of Horn Island Pass more easy of access by the removal of knolls, 1853.

187. The accurate determination of Ship shoal, off the coast of Louisiana, in connexion with the site for a light-house, 1853.

188. An increase of depth of water on the bar of Pass Fourchon, La., 1854.

189. Deep-sea soundings in the Gulf of Mexico, 1855–'56.

190. Tidal phenomena of the Gulf, 1855.

191. The changes at Aransas Pass, Texas, as bearing on the question of a light-house site, 1853.

192. Co-tidal lines of the Gulf of Mexico, 1856.

193. On the effect of wind in disturbing the tides of the Gulf of Mexico, 1856.

194. Development of a bar at the entrance of San Diego bay, Cal., 1856.

195. A shoal inside of Ballast Point, San Diego bay, with only twelve and a half feet of water, not laid down on any chart, 1852.

196. The determination of the position and soundings on Cortez bank, off the coast of California, 1853.

197. Complete hydrographic survey and determination of a point of rock on Cortez shoal, 1856.

198. Tides of San Diego, San Francisco, and Astoria, 1854.

199. The non-existence of San Juan island, usually laid among the Santa Barbara group, 1852.

200. Co-tidal lines of the Pacific coast, 1855.

201. Determination of Uncle Sam Rock, 1855.

202. Investigation of the currents of Santa Barbara channel, 1856.

203. Development in position of the point with only twenty-one feet at mean low water, of Noonday Rock, (called also Fanny shoal,) in the track of vessels passing the North Farallon, approaching San Francisco bay, 1863.

204. Red sand marking the entrance to the Golden Gate, 1855.

205. Determination of the position of the wreck of the ship Flying Dragon, in the track of vessels navigating San Francisco bay, 1863.

206. Channel sounded out between Yerba Buena and the Contra Costa, San Francisco bay, 1855.

207. A reef developed off the Contra Costa flats, San Francisco bay, Cal., 1858.

208. Whiting's Rock determined in position, near the "Brothers," at the entrance of San Pablo bay, Cal., 1858.

209. The further encroachment of the sand-spit at the confluence of Karquines and Mare Island straits upon the channels which lead to the navy yard and to Benicia, 1862.

210. Further development of the extent of Commission Rock, San Pablo bay, 1856.

211. Changes in the channel entrance of Humboldt bay or harbor, Cal., 1852 and 1853.

212. South channel, Columbia river, surveyed and made available to commerce, 1851. Changes of channels, their southward tendency, and a new three-fathom channel from Cape Disappointment due west to open water, Columbia entrance, 1852. Further changes, 1853.

213. The depth of water on the bars at the entrance of Rogue river and Umpquah river, Oregon, 1853.

214. A shoal at the northern entrance to the strait of Rosario, W. T., giving good holding-ground in thirty-three feet, 1854.

215. Boulder reef, northwest of Sinclair island, Rosario strait, partly bare at unusually low tides, and surrounded by kelp, 1854.

216. A bank of three and a half fathoms, about a mile off the southwest point of Sucia island, at the northern entrance of Washington sound, W. T., 1858.

217. Belle Rock, in the middle of Rosario strait, visible only at extreme low tides, 1854.

218. Entrance Rock, at the entrance of Rosario strait, 1854.

219. Unit Rock, in the Canal de Haro, W. T., visible only at extreme low tides, 1854.

220. A three-fathom shoal in the strait of Juan de Fuca, off the southeast part of Bellevue or San Juan island, 1854.

221. Allen's bank, Admiralty inlet, W. T., 1857.

222. A five-fathom shoal in the strait of Juan de Fuca, between Canal de Haro and Rosario strait, 1854.

223. A bank in eleven fathoms off the southern entrance to Canal de Haro, 1854.

224. The non-existence of two islands at the northern entrance of Canal de Haro, laid down on charts, 1853.

225. Various surveys and charts of small harbors on the Pacific coast of the United States, and a continuous reconnaissance of the entire Western Coast and islands adjacent, a great part of which was imperfectly known.

226. Winds of the Western Coast of the United States, 1857.

ADDITIONAL LIST FOR 1864.

1. Determination of the position of Birch Point ledge, with eleven feet of water on it in Wiscasset bay, and of a rock with only four feet, near Clou's ledge, in Sheepscot river, Maine.

2. White Head Ground, about eight miles to the eastward of Cape Elizabeth, Maine, developed in its general direction.

3. A rock in the entrance to New Bedford Harbor, Massachusetts, determined in position.

4. Development of Round shoal, with eleven feet at mean low water, outside of the four-fathom curve off Absecom inlet, New Jersey.

5. Hatteras inlet: the character and extent of recent changes in the depth of water determined by resurveys.

6. Three separate shoals developed by reconnaissance to the southward and eastward of Cape Lookout, North Carolina.

7. Beaufort harbor, North Carolina, re-examined and its hydrographic changes determined.

8. Two new channels developed, leading into Charleston harbor, South Carolina, resulting from changes in the direction of the former channels, and shoaling in the Lawford channel.

9. Hydrographic changes determined at the bar and in the channel of St. John's river, Florida.

10. Mare Island strait resurveyed, and changes developed in the vicinity of the navy yard.

11. Special examination of the flat in San Pablo bay, between San Pablo and Pinole Point.

APPENDIX No. 5.

REPORT BY LIEUTENANT COMMANDER T. S. PHELPS, UNITED STATES NAVY, ASSISTANT COAST SURVEY, ON HIS RECONNAISSANCE OF THE CAPE LOOKOUT SHOALS OFF THE COAST OF NORTH CAROLINA.

UNITED STATES COAST SURVEY STEAMER CORWIN,
Portland, Maine, September 1, 1864.

SIR: I have respectfully to report on a reconnaissance of the Cape Lookout shoals, North Carolina. A survey of this ground, at this season of the year, I found impossible, owing to the constant strong winds and heavy sea which prevail after the middle of June, from April to the above period being, I am informed, about the only season in which a survey can be successfully accomplished on this part of the coast.

During the few days on which I could execute any work the boats could not be used, and I found it too hazardous (having struck in fourteen feet water) to run the steamer where the color of the water indicated three fathoms or less.

The breakers make S. by E. ¼ E., seven and a half miles from the light-house, and are constant with the exception of a space of about two and a half miles, where in moderate weather the sea does not break; and I was informed by the light-house keeper that this space was used by vessels drawing less than nine feet.

From the south point of the constant breakers the shoal continues in the same direction three miles further, or ten and a half miles S. by E. ¼ E. from the light-house. This part of the shoal is indicated by light-green water, varying to a yellow tinge on the shoalest lumps; and is also very "lumpy," the water over the lumps varying in depth from about nine to eighteen feet, and it is on this point south of the constant breakers that the blockade vessels have recently touched. About one mile and a half to the southward and eastward of the above shoal is one on which there is five and a half fathoms water, and still further in the same direction, S.E. by S. ½ S., thirteen and a half miles from the light-house, lies the outer shoal, on which there is five and a quarter fathoms. Beyond this I discovered no indications of shoals With the eye elevated thirteen feet above the water, and ten and a half miles from the light-house, just clear of the dangerous shoal, the ground on which the light-house stands is below, and the lower red stripe of the old light-house is half its width above the horizon; the constant breakers are plain in sight three miles distant.

The lower red stripe, well on the horizon, will carry a vessel around the dangerous shoal in from six to eight fathoms.

On the five and a half fathom shoal the breakers are in sight, with no horizon showing beyond, and when on the outer shoal, in five and a quarter fathoms, the lower edge of the upper red stripe of the old light-house is a little above the horizon, and there are no breakers in sight. With the top of the old light-house just discernible above the horizon, a vessel will be well clear of all shoals, and fifteen miles from the light-house. In from seven to eleven fathoms the color of the water is dark green; in five fathoms a pale green; and in three fathoms and less a very light green, varying according to the depth.

I am, very respectfully, your obedient servant,

THOMAS S. PHELPS,
Lieutenant Commander U. S. Navy, Assistant Coast Survey.

Prof. A. D. BACHE, LL.D.,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 6.

EXTRACTS FROM THE REPORT OF ACTING ASSISTANT EDWARD CORDELL, DESCRIBING HYDROGRAPHIC CHANGES AT BEAUFORT ENTRANCE, NORTH CAROLINA.

BEAUFORT, N. C., *May* 2, 1864.

SIR: I have the honor to report the completion of the resurvey of the entrance to this harbor, from sea to Fort Macon, in accordance with your instructions of March 21. The buoys have been placed so as to mark the line of best water in the channel, and in conformity with the changes that have taken place since the last survey was made. The work was commenced on the 7th of April, and continued up to date. The principal changes in the channel occur at Black buoy, No. 3. It was placed in 1862 in twenty feet of water to mark the point of the southwest breakers. Since then the breakers have extended to the westward about one hundred yards beyond the original position of the buoy, and but eight feet of water was found at its position. It was removed into sixteen feet.

Abreast of Red buoy, No. 4, in mid-channel, a bank has formed with twelve feet of water upon it. Its extent is about four hundred yards in a northwest and southeast direction, with thirteen feet on its eastern and thirteen and a half on its western side. To indicate its position for vessels entering this port, I have shifted buoy No. 4 from the eastern edge of the channel to the west side of the bank into fourteen feet water. By changing the position of Black buoy No. 5 to the southward and eastward to mark a twelve feet spot on the west edge of the channel, the buoying of the best line of water in the channel has been effected.

According to the new survey, fourteen feet was the least water found on the outer bar, and thirteen and a half the best on the inner bar at mean low water. The mean rise and fall of the tides is three feet.

Referring to the chart you will perceive considerable change in the shore line at the northwest point of Shakelford island. A strong current at the mouth of Core sound is washing away that point, and is probably the cause of the formation of the bank in mid-channel, and the making of a new channel to the southward of Black buoy No. 7.

This new channel, as well as the upper part of the harbor, also, will be thoroughly examined during the present month. * * * * In conclusion, I would express my acknowledgments to Commander Dove, of the navy, for his cheerful co-operation and promptness in furnishing means and facilities to carry out your instructions.

Very respectfully, your obedient servant,

EDWARD CORDELL.

Prof. A. D. BACHE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 7.

EXTRACTS FROM THE REPORT OF ACTING ASSISTANT EDWARD CORDELL, RELATIVE TO THE SURVEY OF CORE SOUND, NORTH CAROLINA.

UNITED STATES SCHOONER LENOX,
New Bern, September 9, 1864.

SIR: I have the honor to report the completion of the hydrographic survey of the channel leading through the Straits and Core sound, from Beaufort harbor into Pamplico sound, North Carolina. Five feet of water were found on Harbor Island bar, which depth can also be carried over the shoalest places in the channel through the sound. Southerly winds depress this depth to four feet seven inches, while northerly and easterly winds increase it to nearly six feet. The entrance and bar at Harbor island have been marked by three iron can buoys, painted white and black, in perpendicular stripes. The outer buoy, a second-class can, was placed in seventeen feet of water, sticky bottom, one-fourth of a mile outside the bar; southwest of it three-eighths of a mile is the bar buoy, a third-class can, in five and a half feet; and S. W. by W. $\frac{1}{2}$ W., one-half mile from it, lies the inner buoy in eight and a half feet of water, nearly in the position of the former light-vessel. From here the channel was marked by hand stakes, marking the points of shoals and pointing to the best water, and by running or bush stakes placed at convenient distances from each other in mid-channel. The number of stakes from Beaufort to Harbor island is 135. The entrance into the straits from Beaufort will be marked by a spar-buoy as soon as possible. The mean rise and fall of tides in the straits is one foot and a half nearly; at the entrance of the straits into Core sound, one foot; and at Piney Point, about half-way between Beaufort and Harbor island, four-tenths of a foot. At Harbor island it is barely perceptible.

The current in the sound is feeble, and principally caused by the prevailing winds. * * * * *

Very respectfully, your obedient servant,

EDWARD CORDELL,
Acting Assistant United States Coast Survey.

Prof. A. D. BACHE,
Superintendent United States Coast Survey, Washington, D. C.

APPENDIX No. 8.

TIDE TABLES FOR THE USE OF NAVIGATORS, PREPARED FROM THE COAST SURVEY OBSERVATIONS BY A. D. BACHE, SUPERINTENDENT.

[Furnished, by authority of the Treasury Department, to E. and G. W. Blunt, New York, and revised—1864.]

The following tables will enable navigators to ascertain the time and height of high and low water in some of the principal ports of the United States. The results are approximate, the observations being still in progress, and the period of several of them steadily on the increase as the coast survey advances.

The tides on the coast of the United States, on the Atlantic, Gulf of Mexico, and Pacific, are of three different classes. Those of the Atlantic are of the most ordinary type, ebbing and flowing twice in twenty-four hours, and having but moderate differences in height between the two successive high waters or low waters—one occurring before noon, the other after noon.

Those of the Pacific coast also ebb and flow twice during twenty-four hours, but the morning and afternoon tides differ very considerably in height—so much so that at certain periods a rock which has three feet and a half water upon it at low tide may be awash on the next succeeding low water. The intervals, too, between successive high and successive low waters may be very unequal.

The tides of ports in the Gulf of Mexico, west of Cape St. George, ebb and flow, as a rule, but once in twenty-four hours, or are single-day tides. At particular parts of the month there are two small tides in the twenty-four hours. The rise and fall in all these ports is small. East of Cape St. George the rise and fall increases; there are two tides, as a rule, during the twenty-four hours, and the daily inequality referred to in the Pacific tides is large.

These peculiarities require a different way of treating the cases, and in some of them separate tables.

I propose to enable the navigator to find, from the Nautical Almanac and the following tables, the time and height of high and low water at any date within the ordinary range of difference produced by winds and other variable circumstances. I will endeavor to divest the matter of unfamiliar technical expressions as far as practicable, though, for shortness' sake, some such terms may be employed after defining them. The discussion of the Gulf tides has not been carried so far as to enable me to present the results in as definite a form as the others.

As is well known, the interval between the time of the moon's crossing the meridian (moon's transit) and the time of high water at a given place is nearly constant; that is, this interval varies between moderate limits, which can be assigned. The interval at full and change of the moon is known as the establishment of the port, and is ordinarily marked on the charts. As it is not generally the average of the interval during a month's tides, it is a less convenient and less accurate quantity for the use of the navigation than the average interval which is used on the Coast Survey charts, and is sometimes called the "mean" or "corrected establishment."* The following table gives the principal tidal quantities for the different ports named in the

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* This term was introduced by the Rev. Dr. Whewell, who has done so much for the investigation of the laws of the tides.

first column, where they are arranged under specific heads. The third column of the table gives the mean interval, in hours and minutes, between the moon's transit and the time of high water next after the transit; the fourth, the difference between the greatest and the least interval occurring in different parts of the month, (lunar.) A simple inspection of this column will show how important it is to determine these changes in many of the ports where they amount to more than half an hour, or to more than fifteen minutes from the average interval. The fifth, sixth, and seventh columns refer to the height of the tide. The fifth gives, in feet, the average rise and fall, or average difference between high and low water; the sixth gives the greatest difference, commonly known as the rise and fall of spring tides; and the seventh the least difference, known as the rise and fall of the neap tides.

The average duration of the flood or rising tide is given in the eighth column; of the ebb or falling tide in the ninth; and of the period during which the tide neither rises nor falls, or the "stand," in the tenth. The duration of the flood is measured from the middle of the stand at low water to the middle of the stand at high water, so that the whole duration from one high water to the next, or from one low water to the next, should be given by the sum of the numbers in the eighth and ninth columns. At most of these places given in the list a mark of reference has been established for the height of the tide. I have omitted the description of these marks, (except in the following localities,) as of no particular interest in this connexion.

BENCH-MARKS.

Boston.—The top of the wall or quay at the entrance of the dry dock in the Charlestown navy yard is fourteen feet $\frac{69}{100}$ (or 14.69 feet) above mean low water.*

New York.—The lower edge of a straight line cut in a stone wall at the head of a wooden wharf on Governor's island is thirteen feet $\frac{97}{100}$ (or 13.97 feet) above mean low water. The letters U. S. C. S. are cut in the same stone.

Old Point Comfort, Va.—A line cut in the wall of the light-house, one foot from the ground, on the southwest side, is eleven feet (11 feet) above mean low water.

Charleston, S. C.—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, is ten feet $\frac{13}{100}$ (10.13 feet) above mean low water.

TABLE I.—*Tide table for the coast of the United States.*

PORT.	STATE.	Interval between time of moon's transit and time of high water. Mean interval.	Difference between greatest and least interval.	Rise and fall. Mean.	Spring tides.	Neap tides.	Mean duration of— Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
COAST FROM PORTLAND TO NEW YORK.		*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	*h. m.*	*h. m.*
Eastport	Maine	11 8	0 51	18.1	20.6	15.4	6 3	6 23	....
Hanniwell's Point, Kennebec river	...do	11 15	1 14	8.1	9.3	7.0	6 16	6 11	0 22
Portland	...do	11 25	0 44	8.9	9.9	7.6	6 14	6 12	20
Portsmouth	New Hampshire	11 23	53	8.6	9.9	7.2	6 22	6 7	21
Newburyport	Massachusetts	11 22	50	7.8	9.1	6.6	5 16	7 9	24
Rockport	...do	10 57	42	8.6	10.2	7.1	6 17	6 9	30
Salem	...do	11 13	50	9.2	10.6	7.6	6 19	6 6	6
Boston light	...do	11 12	35	9.3	10.9	8.1	6 20	6 6	15
Boston	...do	11 27	43	10.0	11.3	8.5	6 13	6 13	9
Plymouth	...do	11 19	51	10.2	11.4	9.0	6 13	6 17	29
Wellfleet	...do	11 5	1 13	11.2	13.2	9.2	6 6	6 17	15
Provincetown†	...do	11 22	40	9.2	10.8	7.7	6 16	6 10	21
Monomoy	...do	11 58	37	3.8	5.3	2.6	6 25	5 59	36
Nantucket	...do	12 24	37	3.1	3.6	2.6	6 23	5 44	9

* In consequence of alterations made to the wall during the year 1860 the coping is seven-hundredths of a foot lower than formerly.

† From Major J. D. Graham's observations.

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Difference between greatest and least interval.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
PORTLAND TO NEW YORK—Continued.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
Hyannis	Massachusetts	12 22	30	3.2	3.9	1.8	6 44	5 41	9
Edgartown	...do	12 16	34	2.0	2.5	1.6	6 51	5 29	24
Holmes's Hole	...do	11 43	31	1.7	1.8	1.3	6 41	5 21	12
Tarpaulin Cove	...do	8 4	49	2.3	2.8	1.8	6 9	6 17	34
Wood's Hole, north side	...do	7 59	53	4.0	4.7	3.1	6 51	5 31	38
Wood's Hole, south side	...do	8 34	45	1.6	2.0	1.2	5 17	7 10	59
Menemsha Bight	...do	7 45	1 0	2.7	3.9	1.8	6 14	6 14	4
Quick's Hole, north side	...do	7 31	1 15	3.7	4.3	2.9	6 31	5 54	39
Quick's Hole, south side	...do	7 36	1 10	3.1	3.8	2.3	6 29	5 55	40
Cuttyhunk	...do	7 40	49	3.5	4.2	2.9	6 31	5 54	39
Kettle Cove	...do	7 48	1 0	4.3	5.0	3.7	6 17	6 4	29
Bird Island light	...do	7 59	45	4.4	5.3	3.5	6 51	5 58	....
New Bedford entrance, (Dumpling Rock)	...do	7 57	41	3.8	4.6	2.8	6 50	5 33	42
Newport	Rhode Island	7 45	24	3.9	4.6	3.1	6 21	6 3	23
Point Judith	...do	7 32	46	3.1	3.7	2.6	6 12	6 10	1 0
Block island	...do	7 36	41	2.8	3.5	2.0	6 23	6 2	5
Montauk Point, L. I	New York	8 20	1 11	1.9	2.4	1.8	6 17	6 7	31
Sandy Hook	...do	7 29	47	4.8	5.6	4.0	6 10	6 15	21
New York	...do	8 13	43	4.3	5.4	3.4	6 0	6 25	28
HUDSON RIVER.									
Dobb's Ferry	New York	9 19	44	3.6	4.4	2.7	6 5	6 18	17
Tarrytown	...do	9 57	58	3.5	4.0	2.7	6 6	6 20	43
Verplanck's Point	...do	10 8	34	3.1	3.8	2.5	5 25	7 12	16
West Point	...do	11 2	37	2.7	3.2	2.0	5 28	7 10	20
Poughkeepsie	...do	12 34	54	3.2	3.9	2.4	5 41	6 44	22
Tivoli	...do	1 24	51	4.0	4.6	3.2	5 40	6 54	25
Stuyvesant	...do	3 23	48	3.8	4.4	3.0	5 18	7 2	31
Castleton	...do	4 29	55	2.7	3.0	2.3	5 1	7 23	20
Greenbush	...do	5 22	40	2.3	2.5	1.9	4 26	7 59	....
LONG ISLAND SOUND.									
Watch Hill	Rhode Island	9 0	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Connecticut	9 7	30	2.7	3.2	2.2	6 15	6 10	25
Little Gull island	New York	9 38	1 7	2.5	2.9	2.3	6 1	6 21	37
New London	Connecticut	9 28	52	2.6	3.1	2.1	5 56	6 26	22
New Haven	...do	11 16	1 8	5.9	6.2	5.2	6 24	6 5	33
Bridgeport	...do	11 11	1 3	6.5	8.0	4.7	6 1	6 7	30
Oyster Bay, L. I	New York	11 7	51	7.3	9.2	5.4	6 8	6 24	25
Sand's Point, L. I	...do	11 13	31	7.7	8.9	6.4	5 55	6 30	14
New Rochelle	...do	11 22	32	7.6	8.6	6.6	5 51	6 35	12
Throg's Neck	...do	11 20	39	7.3	9.2	6.1	5 50	6 33	43
COAST OF NEW JERSEY.									
Cold Spring inlet	New Jersey	7 32	0 51	4.4	5.4	3.6	6 8	6 18	19
Cape May landing	...do	8 19	47	4.8	6.0	4.3	6 11	6 15	20
DELAWARE BAY AND RIVER.									
Delaware breakwater	Delaware	8 0	50	3.5	4.5	3.0	6 15	6 6	26
Higbee's, Cape May	New Jersey	8 33	43	4.9	6.2	3.9	6 26	6 0	19
Egg Island light	...do	9 4	51	6.0	7.0	5.1	5 52	5 27	36
Mahon's river	Delaware	9 52	48	5.9	6.9	5.0	6 11	6 11	26
Newcastle	...do	11 53	24	6.5	6.9	6.0	5 6	5 43	47
Philadelphia	Pennsylvania	13 44	44	6.0	6.8	5.1	4 52	7 6	15
CHESAPEAKE BAY AND RIVERS.									
Old Point Comfort*	Virginia	8 46	52	2.5	3.0	2.0	6 1	6 25	14
Point Lookout	Maryland	12 58	45	1.4	1.9	0.7	5 59	6 19	35

* The mean interval has been corrected from later and more reliable observations.

TABLE I—Continued.

PORT.	STATE.	Interval between time of moon's transit and time of high water. Mean interval.	Difference between greatest and least interval.	Rise and fall. Mean.	Spring tides.	Neap tides.	Mean duration of— Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
CHESAPEAKE BAY AND RIVERS—Cont'd.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
Annapolis	Maryland	17 4	40	0.9	1.0	0.8	6 11	6 15	32
Bodkin light	....do	18 8	48	1.0	1.3	0.8	5 23	7 8	15
Baltimore	....do	18 59	44	1.3	1.5	0.9	5 54	6 33	44
Washington	District of Columbia	20 10	52	3.0	3.4	2.6	5 37	6 49	....
James river, (City Point)	Virginia	14 37	1 0	2.8	3.0	2.5	5 14	6 58	32
Richmond	....do	16 54	1 6	2.9	3.4	2.3	4 53	7 31	35
Tappahannock	....do	13 8	46	1.6	1.9	1.3	5 21	7 6	....
COAST OF NORTH AND SOUTH CAROLINA, GEORGIA, AND FLORIDA.									
Hatteras inlet	North Carolina	7 4	57	2.0	2.2	1.8	6 7	6 7	50
Beaufort	....do	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Bald Head	....do	7 26	34	4.3	5.0	3.4	6 18	6 17	31
Smithville	....do	7 19	38	4.5	5.5	3.8	6 1	6 26	26
Wilmington	....do	9 6	1 0	2.7	3.1	2.2	4 45	7 40	30
Georgetown entrance	South Carolina	7 56	42	3.8	4.7	2.7	6 4	6 19	35
Bull's Island bay	....do	7 16	57	4.8	5.7	3.7	6 20	6 6	30
Charleston, (custom-house wharf)	....do	7 26	48	5.1	6.0	4.1	6 19	6 7	33
St. Helena sound	....do	7 8	1 0	5.9	7.4	4.4	6 13	6 12	23
Fort Pulaski, (Savannah entrance)	Georgia	7 20	40	7.0	8.0	5.9	5 49	6 35	26
Savannah, (dry-dock wharf)	....do	8 13	51	6.5	7.6	5.5	5 4	7 22	14
Doboy light-house	....do	7 33	55	6.6	7.8	5.4	6 2	6 20	....
St. Simon's	....do	7 43	46	6.8	8.2	5.4	6 10	6 16	20
Fort Clinch	Florida	7 53	1 6	5.9	6.7	5.3	6 9	6 17	....
St. John's river	....do	7 28	48	4.5	5.5	3.7	5 58	6 28	16
St. Augustine	....do	8 21	43	4.2	4.9	3.6	6 5	6 11	32
Cape Florida	....do	8 34	51	1.5	1.8	1.2	6 0	6 26	45
Indian key	....do	8 23	49	1.8	2.2	1.3	6 25	5 59	19
Sand key	....do	8 40	....	1.2	2.0	0.6	6 31	5 55	13
Key West	....do	9 30	1 15	1.3	1.5	0.9	6 55	5 29	12
Tortugas	....do	9 56	1 32	1.2	1.5	0.6	6 43	5 40	....
Charlotte harbor	....do	13 9	1 38	1.1	1.3	0.8	6 51	5 35	....
Tampa Bay, (Egmont key)	....do	11 21	1 33	1.4	1.8	1.0	6 36	6 11	43
Cedar Keys, (Depot key)	....do	13 15	1 55	2.6	3.2	1.6	6 12	6 13	....
St. Mark's	....do	13 38	2 0	2.2	2.9	1.4	6 12	6 11	....
WESTERN COAST.									
San Diego	California	9 38	1 35	3.7	5.0	2.3	6 22	6 0	30
San Pedro	....do	9 39	1 48	3.7	4.7	2.2	6 18	6 5	30
Cuyler's harbor	....do	9 25	1 2	3.7	5.1	2.8	6 13	6 5	....
San Luis Obispo	....do	10 8	1 52	3.6	4.8	2.4	6 25	5 58	....
Monterey	....do	10 22	49	3.4	4.3	2.5	6 31	6 2	35
South Farallon	....do	10 37	1 16	3.6	4.4	2.8	6 18	6 9	....
San Francisco, (north beach)	....do	12 6	1 4	3.6	4.3	2.8	6 39	5 51	34
Mare island, (San Francisco bay)	....do	13 40	1 15	4.8	5.2	4.1	6 13	6 7	....
Benicia, (San Francisco bay)	....do	14 10	1 0	4.5	5.1	3.7	6 26	5 59	....
Ravenswood, (San Francisco bay)	....do	12 36	57	6.3	7.3	4.9	6 15	6 11	....
Bodega	....do	11 17	1 54	3.6	4.7	2.7	6 19	5 59	....
Humboldt bay	....do	12 2	1 11	4.4	5.5	3.5	6 19	6 0	....
Port Orford	Oregon	11 26	1 6	5.1	6.8	3.7	6 19	6 7	39
Astoria	....do	12 42	1 13	6.1	7.4	4.6	6 3	6 28	33
Nee-ah harbor	Washington	12 33	1 28	5.6	7.4	4.8	6 20	6 6	....
Port Townshend*	....do	3 49	1 3	4.6	5.5	4.0	6 34	5 52	....
Steilacoom*	....do	4 46	1 6	9.2	11.1	7.2	6 3	6 25	28
Semi-ah-moo bay*	....do	4 50	1 2	5.7	6.6	4.8	6 11	6 19	26

* See remarks on page 92, and following.

NOTE.—The mean interval in column 3 has been increased by 12*h*. 26*m*. (half a mean lunar day) for some of the ports in Delaware river and Chesapeake bay, so as to show the succession of times from the mouth. Therefore 12*h*. 26*m*. ought to be subtracted from the establishments which are greater than that quantity before using them.

The foregoing Table I gives the means of determining, roughly, the time and height of high water at the several ports named. The hour of transit of the moon preceding the time of high water is to be taken from the Almanac, and, the mean establishment being added, the time of high water results. Thus:

Example I.—It is required to find the time of high water at New York on November 5, 1854. The American Almanac gives 0*h*. 0*m*. as the time of transit of the moon on that day. The mean interval for New York, from Table I, column 3, is 8*h*. 13*m*., which, as the transit was at 0*h*., is, roughly, the time of high water. The moon being full, the height is that of spring tides of column 6, viz: 5.4 feet. If the soundings on the chart are reduced to low-water spring tides, 5.4 feet are to be added to them to give the depth at high water. If the soundings are reduced to mean low water, the rise and fall of mean tides being 1.1 foot less than for springs, the rise or increase of depth will be half of this, or 0.6 of a foot less than 5.4 feet, which is 4.8 feet, or nearly four feet ten inches.

Example II.—Required the time of high water at Boston on January 23, 1851. From the American Almanac we find the time of the moon's southing or transit on that day 5*h*. 18*m*. a. m., and from Table I the mean interval at Boston dry dock is 11*h*. 27*m*.

We have then 5*h*. 18*m*., time of transit.
To which add 11 27 mean interval from Table I.

16 45 time of high water, or 4*h*. 45*m*. p. m.

If the Greenwich Nautical Almanac is used, add 2*m*. to the time of transit of Greenwich for every hour of west longitude, and its proportional part for less than an hour. It will suffice to take the half hour which may be over any number of hours, as the correction for less than this would be less than one minute, and need not be taken into account. Thus, Boston is 4*h*. 44*m*. west of Greenwich. The correction to be applied to the time of transit of the moon is, for the four hours, eight minutes, and for the forty-four minutes, one minute. The time of transit on the date assumed in the preceding example is 17*h*. 9*m*. of the 22d, or 5*h*. 9*m*. a. m. of the 23d, to which add nine minutes, the correction just found, gives 5*h*. 18*m*., as before ascertained from the American Almanac.

In using the United States Nautical Almanac, in the astronomical part of which the transits of the moon are given for the meridian of Washington, the corrections required may, in this first approximation for the Atlantic coast, be neglected. To find the time of the next following low water, add, from Table I, the duration of ebb tide.

This gives 4*h*. 45*m*. p. m., time of high water.
6 13 duration of ebb from Table I.

10 58 p. m.

By subtracting the duration of flood tide we obtain the time of the preceding low water, 10*h*. 32*m*. a. m., recollecting that 4*h*. 45*m*. p. m. is the same as 16*h*. 45*m*. reckoned from midnight.

The height of this tide, corresponding to the transit of 5*h*., will bring it nearly to a neap tide, and the rise and fall obtained from column 7, Table I, is 8.5 feet. The next following high water may be had by adding to the time of low water the duration of flood from Table I; thus:

10*h*. 58*m*. p. m., time of low water January 23.
6 13 duration of flood from Table I.

Sum 17 11 or 5*h*. 11*m*. on January 24.

Or, having found the time of high water, the time of the next following high water may be found by adding the duration of flood and ebb together, and their sum to the time of high water found; thus:

6*h*. 13*m*., duration of ebb tide from Table I.
6 13 duration of flood.

Sum 12 26 duration of whole tide.
4 45 p. m., January 23, time of high water.

Sum 17 11 or 5*h*. 11*m*. a. m, January 24, time of the next succeeding high water.

Subtracting the same quantity will give the time of the preceding high water; thus:

$4h.\ 43m.$ p. m., or $16h.\ 45m.$ from midnight, is the time of high water.

12 26 duration of flood and ebb tide.

4 19 a. m. of the 23d for the preceding high water.

The duration of the flood and the ebb being reckoned from the middle of one stand or slack water to the middle of the next, the time of beginning of stand of ebb or flood will be found by subtracting half the duration of stand or slack water given by column 10, Table I, from the time of high or low water, and the time of the end of the stand of ebb or flood by adding the same. A nearer approximation to the times and heights of high water may be obtained by the use of Tables II and III.

TABLE II.

Interval between the time of moon's transit and the time of high water for different hours of transit, and for several different ports

Time of moon's transit.	Boston, Mass.	New York, N. Y.	Philadelphia, Pa.	Old Point Comfort, Va.	Baltimore, Md.	Smithville, N. C.	Charleston, S. C.	Ft. Pulaski, Savannah, Ga.	Key West, Fla.	San Francisco, Cal.
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	11 38	8 20	1 31	8 55	6 47	7 26	7 38	7 30	9 33	12 5
0 30	11 33	8 18	1 28	8 49	6 42	7 21	7 33	7 25	9 26	11 59
1 0	11 28	8 15	1 25	8 44	6 37	7 16	7 27	7 19	9 19	11 53
1 30	11 24	8 10	1 21	8 40	6 31	7 13	7 21	7 15	9 13	11 47
2 0	11 20	8 6	1 18	8 35	6 26	7 9	7 16	7 11	9 6	11 41
2 30	11 16	8 0	1 14	8 32	6 21	7 6	7 12	7 8	9 1	11 36
3 0	11 13	7 55	1 11	8 27	6 17	7 4	7 8	7 6	8 57	11 33
3 30	11 10	7 52	1 8	8 22	6 13	7 3	7 5	7 5	8 53	11 33
4 0	11 7	7 52	1 6	8 20	6 11	7 2	7 2	7 4	8 53	11 38
4 30	11 6	7 52	1 3	8 21	6 10	7 3	7 2	7 3	8 56	11 46
5 0	11 6	7 53	1 0	8 23	6 10	7 4	7 3	7 4	9 2	11 55
5 30	11 9	7 56	0 59	8 26	6 13	7 6	7 7	7 6	9 10	12 3
6 0	11 13	7 59	0 59	8 32	6 19	7 9	7 12	7 8	9 22	12 11
6 30	11 19	8 5	1 1	8 39	6 25	7 13	7 19	7 12	9 33	12 16
7 0	11 25	8 11	1 7	8 48	6 32	7 17	7 24	7 16	9 49	12 23
7 30	11 32	8 17	1 15	8 58	6 39	7 23	7 32	7 22	10 0	12 29
8 0	11 38	8 23	1 23	9 4	6 44	7 28	7 38	7 28	10 6	12 34
8 30	11 43	8 27	1 29	9 8	6 49	7 33	7 45	7 34	10 7	12 37
9 0	11 47	8 32	1 34	9 10	6 52	7 37	7 48	7 39	10 6	12 36
9 30	11 48	8 34	1 39	9 12	6 54	7 39	7 50	7 42	10 3	12 34
10 0	11 49	8 35	1 42	9 10	6 53	7 40	7 50	7 43	9 59	12 30
10 30	11 48	8 34	1 43	9 8	6 52	7 40	7 47	7 41	9 56	12 24
11 0	11 47	8 31	1 41	9 4	6 50	7 36	7 44	7 37	9 48	12 17
11 30	11 43	8 25	1 37	9 2	6 48	7 30	7 41	7 34	9 40	12 9

TABLE III.

Showing the rise and fall of tides, and corrections to be applied to determine the depth at high water of soundings on charts referred to mean low water, and to low water spring tides.

Time of moon's transit.	Boston, Mass.			New York, N. Y.			Philadelphia, Pa.			Old Point Comfort, Va.			Baltimore, Md.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	11.2	10.6	11.3	4.9	4.5	4.9	6.3	6.2	6.3	2.9	2.6	2.9	1.5	1.4	1.6	0
1	11.3	10.6	11.3	4.9	4.5	4.9	6.4	6.4	6.5	3.0	2.7	3.0	1.5	1.4	1.6	1
2	11.2	10.5	11.2	4.7	4.4	4.8	6.6	6.5	6.6	2.9	2.7	2.9	1.5	1.3	1.5	2
3	10.6	10.3	10.0	4.3	4.2	4.6	6.6	6.5	6.6	2.6	2.6	2.8	1.4	1.3	1.5	3
4	10.0	10.0	10.7	3.8	4.0	4.4	6.4	6.4	6.5	2.3	2.4	2.7	1.3	1.2	1.4	4
5	9.2	9.7	10.4	3.5	3.8	4.2	6.1	6.2	6.3	2.1	2.3	2.6	1.1	1.1	1.3	5
6	8.8	9.4	10.1	3.3	3.7	4.1	5.7	5.9	6.0	2.0	2.2	2.5	0.9	1.1	1.3	6
7	8.6	9.3	10.0	3.3	3.7	4.1	5.4	5.6	5.7	2.0	2.3	2.5	0.9	1.1	1.3	7
8	8.9	9.5	10.2	3.6	3.8	4.2	5.2	5.3	5.4	2.2	2.4	2.6	1.0	1.2	1.4	8
9	9.4	9.7	10.4	4.0	4.0	4.4	5.4	5.4	5.5	2.5	2.5	2.8	1.1	1.3	1.5	9
10	10.1	10.0	10.7	4.5	4.3	4.7	5.7	5.7	5.8	2.8	2.7	2.9	1.3	1.4	1.6	10
11	10.7	10.3	11.0	5.8	4.5	4.9	6.0	6.0	6.1	3.0	2.8	3.0	1.4	1.4	1.6	11

TABLE III—Continued.

Time of moon's transit.	Smithville, N. C.			Charleston, S. C.			Fort Pulaski, Savannah entrance.			Key West, Fla.			San Francisco, Cal.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	5.2	4.8	5.1	6.0	5.5	6.0	7.8	7.4	7.8	1.5	1.4	1.5	4.5	4.0	4.4	0
1	5.1	4.8	5.1	5.9	5.5	5.9	7.9	7.4	7.9	1.5	1.4	1.5	3.9	3.7	4.1	1
2	5.0	4.7	5.0	5.7	5.4	5.8	7.6	7.3	7.7	1.5	1.4	1.5	3.7	3.6	4.1	2
3	4.6	4.5	4.8	5.3	5.2	5.6	7.1	7.0	7.5	1.4	1.3	1.4	3.5	3.5	4.0	3
4	4.3	4.4	4.7	4.7	4.9	5.4	6.5	6.7	7.2	1.2	1.2	1.3	3.1	3.3	3.8	4
5	4.0	4.3	4.6	4.4	4.8	5.2	6.1	6.5	7.0	1.0	1.1	1.2	2.8	3.1	3.6	5
6	3.8	4.2	4.5	4.2	4.6	5.1	5.8	6.4	6.8	0.9	1.0	1.1	2.7	3.1	3.6	6
7	3.8	4.1	4.4	4.3	4.7	5.1	6.0	6.5	6.9	0.9	1.1	1.2	3.0	3.3	3.7	7
8	4.0	4.2	4.5	4.5	4.8	5.3	6.4	6.7	7.1	1.0	1.2	1.3	3.4	3.5	3.9	8
9	4.3	4.3	4.6	5.0	5.0	5.5	6.9	6.9	7.4	1.2	1.3	1.4	3.8	3.6	4.1	9
10	4.7	4.6	4.9	5.5	5.3	5.8	7.4	7.0	7.6	1.4	1.4	1.5	4.0	3.8	4.2	10
11	5.0	4.7	5.0	5.9	5.5	5.9	7.8	7.2	7.8	1.5	1.4	1.5	4.2	3.8	4.3	11

In these the variations in the interval between the moon's transit and high water are shown for some of the principal ports contained in Table I. These variations of intervals depend upon the age of the moon, and, as they go through their values in half a lunar month, are known as the half-monthly inequality of interval. The table extends from the *0h.* of transit, midnight of the calendar day, or full of the moon, to 11½ hours. The numbers for change of the moon correspond to those of *0h.*, and for 13 hours (or *1h.* p. m. of the calendar day) to 1 hour, and so on up to 23 hours. The ports for which the numbers are given are designated by the heading of the column.

The mean interval, it will be seen, does not occur at full and change, but nearly two days afterwards, on the Atlantic coast. At Key West it occurs more nearly at full and change, and at San Francisco still more nearly.

The same remark applies to the heights; spring tides occur about two days after the full and change of the moon, and neaps two days after the first and last quarters. The use of this table of nearer approximation is quite as simple as that of Table I.

Rule to find the time of high water.—Look in the Almanac for the time of the moon's transit (or southing) for the date required. In the table corresponding to that time will be found the number to be added to the time of transit.

Example III.—Required, the time of high water at New York October 1, 1856. Using the United States Nautical Almanac, we find the time of the moon's transit 1*h*. 24*m*., astronomical reckoning, or 1*h*. 24*m*. p. m. calendar time. From Table II we have, under the heading of New York, for 1*h*. 30*m*. (the nearest number to 1*h*. 24*m*. in the table) 8*h*. 10*m*.

Thus, to 1*h*. 24*m*., time of moon's transit,
Add 8 10 interval found in Table III.

The sum 9 34 p. m. is the time of high water on the 1st of October, 1856.

If the sum of these numbers had exceeded twelve, the tide would have belonged to October 2, and we must have gone back to the transit of the day before and computed with it to obtain the tide of October 1.

Rule to find the height of high water.—Enter Table III, column 1, with the time of moon's transit. In the column headed with the name of the place, and marked A, will be found the rise and fall corresponding to the time of transit; in column B the number to be added to soundings on the chart, where the soundings are given for mean low water; in column C the number to be added to charts of which the soundings are given for low water spring tides.

In the foregoing example, (III,) the time of transit being between 1 and 2 hours, we find from Table III the rise and fall of tides on the 1st of October, 1856, between 4.9 and 4.7; the number to be added to sounding given for mean low water 4.5 feet, (column B,) and for low water spring tides (column C) 4.9 feet.

Having found the time of high water, that of low water may be obtained, nearly, by adding the duration of ebb from column 9, Table I. The time of the next preceding low water may be found by subtracting the duration of flood from column 8, Table I. The time of the next following high water may be found by adding the duration of both flood and ebb, and of the next preceding high water by subtracting the same duration of the whole tide.

Example IV.—To find the next high water following that of Example III.

The duration of flood, column 8, Table I, for New York, is 6*h*. 0*m*.; and of ebb, from column 9, is 6*h*. 25*m*.; the sum is 12*h*. 25*m*.

To 9*h*. 34*m*. p. m., October 1, time of high water found,
Add 12 25 duration of flood and ebb.

Sum 21 59 or 9*h*. 59*m*. a. m. of October 2, the time of the next high water.

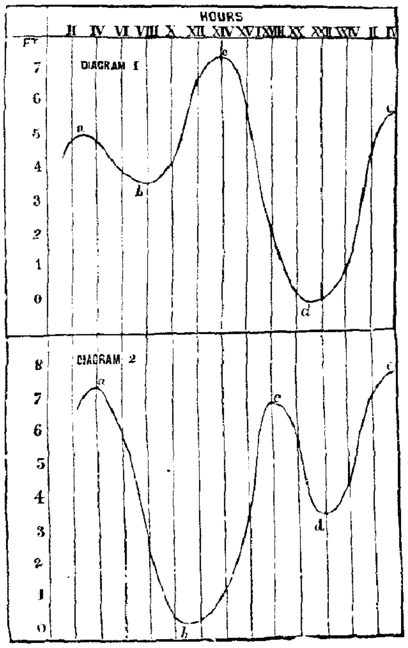
TIDES OF THE PACIFIC COAST AND OF PART OF THE COAST OF FLORIDA.

On the Pacific coast there are, as a general rule, one large and one small tide during the day, the height of the two successive high waters occurring one a. m. the other p. m. of the same twenty-four hours, and the intervals from the next preceding transit of the moon are very different. The inequalities depend upon the moon's declination; they disappear near the time of the moon's declination being nothing, and are greatest about the time of its being greatest. The inequalities for low water are not the same as for high, though they disappear and have the greatest value at nearly the same times. The tides of the southern part of Florida and of the western coast of that peninsula, as far as St. Mark's, are of the same character.

In Puget's sound the inequalities for the interval of high water and for the height of low water follow this rule; but those for the interval of low water and height of high water disappear about one day before the moon's declination is greatest, and are greatest about four or five days before the greatest declination.

When the moon's declination is north, the highest of the two tides of the twenty-four hours occurs at San Francisco about eleven and a half hours after the moon's southing, (transit;) and when the declination is south, the lowest of the two high tides occurs about that interval.

The lowest of the two low waters of the day is one which follows next the highest high water. The nature of these tides will probably appear more plainly from the annexed diagrams. In them the height of



the tide is set off at the side on a scale of feet, and the hours of the day are at the top. At 12 noon, for example, the tide-gauge marked 6.7 feet. Joining all the heights observed in the twenty-four hours, we have a curve like that marked in the figure. The two high waters are *a* and *c*; the two low waters *b* and *d*. If *a* is the high water which occurs about twelve hours after the transit of the moon, when the declination is south, the ebb *a b* is quite small, and the high water, *a*, is much lower than the next high water, *c*. If the moon's declination is north, it is the large high water, *a*, of the second diagram which occurs next after the transit, and about twelve hours from it. At Key West the contrary obtains, diagram 1 applying when the moon's declination is north, and diagram 2 when south. Tables IV and V give the number to be added to the time of moon's transit to find the time of high water almost as readily as in the former case. They are of double entry, the time of transit being, as before, placed in the first column. The number of days from the day at which the moon had the greatest declination is arranged at the top of the table. Entering the first column with the time of transit, and following the line horizontally until we come under the column containing the days from the greatest declination, we find the number to be added to the time of the transit to give the time of high water. If the moon's declination is south, Table IV is to be used; if north, Table V.

Tables IV to IX, inclusive, have been recomputed, using more complete data for the inequalities above referred to, and to those for San Francisco similar tables have been added for San Diego, Astoria, Port Townshend, and Key West, Fla. For the other places on the Western Coast given in Table I the following rules will give sufficiently close approximations.

To obtain the times of high or low water for San Pedro, Cuyler's harbor, and San Luis Obispo, compute first the time for San Diego by Tables IV, V, or VIII; then add to the time thus obtained 30 minutes to obtain the time for San Luis Obispo, and subtract 13 minutes for Cuyler's harbor. At San Pedro the time of high or low water is sensibly the same as at San Diego.

For Monterey, South Farallon, Mare Island, Benicia, Ravenswood, and Bodega, compute first the time for San Francisco; then subtract from the time thus obtained 1*h*. 44*m*. for Monterey, 1*h*. 29*m*. for the South Farallon, and 49*m*. for Bodega, and add 34*m*. for Mare Island, 1*h*. 4*m*. for Benicia, and 30*m*. for Ravenswood. For Humboldt bay, Port Orford, and Neeah harbor, compute first the time for Astoria; then subtract from it 40*m*. for Humboldt bay, 1*h*. 16*m*. for Port Orford, and 9*m*. for Neeah harbor.

For Steilacoom and Semiahmoo bay, compute first the time for Port Townshend, and add to it 57*m*. for Steilacoom and 1*h*. for Semiahmoo. The approximation will be only a rough one for Steilacoom.

For the heights, Tables VI, VII, and IX for San Diego can be used without change for San Pedro, Cuyler's harbor, and San Luis Obispo. These tables for San Francisco are also applicable to Monterey, South Farallon, and Bodega. For Mare Island add 1.2 foot, for Benicia 0.9 foot, and for Ravenswood 2.7 feet, to the quantities for San Francisco.

For Humboldt bay, Port Orford, and Neeah harbor, the tables for Astoria may be used, subtracting 1.7 foot for Humboldt bay, and 1.0 foot for Port Orford. For Neeah harbor the tables will give approximate results without change.

For Semiahmoo bay, add one foot to the quantities in the tables for Port Townshend. For Steilacoom, a rough approximate may be obtained by adding 4.6 feet to them.

For the coast of Florida, compute the times of high or low water for Key West, and subtract 1*h*. 7*m*. for Indian key, and add 26*m*. for Tortugas, 3*h*. 39*m*. for Charlotte harbor, 1*h*. 51*m*. for Egmont key, 3*h*. 45*m*. for Cedar keys, and 4*h*. 8*m*. for St. Mark's. For the heights, add half a foot for Indian key, and use the tables without change for Tortugas and Egmont key. For Cedar keys and St. Mark's the results could not be obtained with much accuracy in this way; special tables will be prepared for those places.

TABLE IV.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
0 30	9 33	9 23	9 11	9 00	8 54	8 42	8 37	8 33	8 33	8 39	8 47	8 59	9 09	9 20	9 30
1 0	9 26	9 16	9 04	8 53	8 47	8 35	8 30	8 26	8 26	8 32	8 40	8 52	9 02	8 13	9 23
1 30	9 20	9 10	8 58	8 47	8 41	8 29	8 24	8 20	8 20	8 26	8 34	8 46	8 56	9 07	9 17
2 0	9 13	9 03	8 51	8 40	8 34	8 22	8 17	8 13	8 13	8 19	8 27	8 39	8 49	9 00	9 10
2 30	9 08	8 58	8 46	8 35	8 29	8 17	8 12	8 08	8 08	8 14	8 22	8 34	8 44	8 55	9 05
3 0	9 04	8 54	8 42	8 31	8 25	8 13	8 08	8 04	8 04	8 10	8 18	8 30	8 40	8 51	9 01
3 30	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 0	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 30	9 03	8 53	8 41	8 30	8 24	8 12	8 07	8 03	8 03	8 09	8 17	8 29	8 39	8 50	9 00
5 0	9 09	8 59	8 47	8 36	8 30	8 18	8 13	8 09	8 09	9 15	8 23	8 35	8 45	8 56	9 06
5 30	9 17	9 07	8 55	8 44	8 38	8 26	8 21	8 17	8 17	8 23	8 31	8 43	8 53	9 04	9 14
6 0	9 29	9 19	9 07	8 56	8 50	8 38	8 33	8 29	8 29	8 35	8 43	8 55	9 05	9 16	9 26
6 30	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
7 0	9 56	9 46	9 34	9 23	9 17	9 05	9 00	8 56	8 56	9 02	9 10	9 22	9 32	9 43	9 53
7 30	10 07	9 57	9 45	9 34	9 28	9 16	9 11	9 07	9 07	9 13	9 21	9 33	9 43	9 54	10 04
8 0	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 00
8 30	10 14	10 04	9 52	9 41	9 35	9 23	9 18	9 14	9 14	9 20	9 28	9 40	9 50	10 01	10 11
9 0	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 10
9 30	10 10	10 00	9 48	9 37	9 31	9 19	9 14	9 10	9 10	9 16	9 24	9 36	9 46	9 57	10 07
10 0	10 06	9 56	9 44	9 33	9 27	9 15	9 10	9 06	9 06	9 12	9 20	9 32	9 42	9 53	10 03
10 30	10 03	9 53	9 41	9 30	9 24	9 12	9 07	9 03	9 03	9 09	9 17	9 29	9 39	9 50	10 00
11 0	9 55	9 45	9 33	9 22	9 16	9 04	8 59	8 55	8 55	9 01	9 09	9 21	9 31	9 42	9 52
11 30	9 47	9 37	9 25	9 14	9 08	8 56	8 51	8 47	8 47	8 53	9 01	9 13	9 23	9 34	9 44

TABLE V.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
0 30	9 22	9 29	9 36	9 46	9 59	10 09	10 15	10 15	10 15	10 11	9 59	9 49	9 36	9 27	9 20
1 0	9 15	9 22	9 29	9 39	9 52	10 02	10 08	10 08	10 08	10 04	9 52	9 42	9 29	9 20	9 13
1 30	9 09	9 16	9 23	9 33	9 46	9 56	10 02	10 02	10 02	9 58	9 46	9 36	9 23	9 14	9 07
2 0	9 02	9 09	9 16	9 26	9 39	9 49	9 55	9 55	9 55	9 51	9 39	9 29	9 16	9 07	9 00
2 30	8 57	9 04	9 11	9 21	9 34	9 44	9 50	9 50	9 50	9 46	9 34	9 24	9 11	9 02	8 55
3 0	8 53	9 00	9 07	9 17	9 30	9 40	9 46	9 46	9 46	9 42	9 30	9 20	9 07	8 58	8 51
3 30	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 0	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 30	8 52	8 59	9 06	9 16	9 29	9 39	9 45	9 45	9 45	9 41	9 39	9 29	9 06	8 57	8 50
5 0	8 58	9 05	9 12	9 22	9 35	9 45	9 51	9 51	9 51	9 47	9 35	9 25	9 12	9 03	8 56
5 30	9 06	9 13	9 20	9 30	9 43	9 53	9 59	9 59	9 59	9 55	9 43	9 33	9 20	9 11	9 04
6 0	9 18	9 25	9 32	9 42	9 55	10 05	10 11	10 11	10 11	10 07	9 55	9 45	9 32	9 23	9 16
6 30	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
7 0	9 45	9 52	9 59	10 09	10 22	10 32	10 38	10 38	10 38	10 34	10 22	10 12	9 59	9 50	9 43
7 30	9 56	10 03	10 10	10 20	10 33	10 43	10 49	10 49	10 49	10 45	10 33	10 23	10 10	10 01	9 54
8 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
8 30	10 03	10 10	10 17	10 27	10 40	10 50	10 56	10 56	10 56	10 52	10 40	10 30	10 17	10 08	10 01
9 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
9 30	9 59	10 06	10 13	10 23	10 36	10 46	10 52	10 52	10 52	10 48	10 36	10 26	10 13	10 04	9 57
10 0	9 55	10 02	10 09	10 19	10 32	10 42	10 48	10 48	10 48	10 44	10 32	10 22	10 09	10 00	9 53
10 30	9 52	9 59	10 06	10 16	10 29	10 39	10 45	10 45	10 45	10 41	10 29	10 19	10 06	9 57	9 50
11 0	9 44	9 51	9 58	10 08	10 21	10 31	10 37	10 37	10 37	10 33	10 21	10 11	9 58	9 49	9 42
11 30	9 36	9 43	9 50	10 00	10 13	10 23	10 29	10 29	10 29	10 25	10 13	10 03	9 50	9 41	9 34

TABLE IV.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 25	9 40	9 52	10 3	10 12	10 20	10 25	10 29	10 29	10 25	10 19	10 10	10 0	9 47	9 30
0 30	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 27	9 20
1 0	9 8	9 23	9 35	9 46	9 55	10 3	10 8	10 12	10 12	10 8	10 2	9 53	9 43	9 30	9 13
1 30	9 1	9 16	2 28	9 39	9 48	9 56	10 1	10 5	10 5	10 1	9 55	9 46	9 36	9 23	9 6
2 0	8 54	9 9	9 21	9 32	9 41	9 49	9 54	9 58	9 58	9 54	9 48	9 39	9 29	9 16	8 59
2 30	8 49	9 4	9 16	9 27	9 36	9 44	9 49	9 53	9 53	9 49	9 43	9 34	9 24	9 11	8 54
3 0	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
3 30	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
4 0	8 52	9 7	9 19	9 30	9 39	9 47	9 52	9 56	9 56	9 52	9 46	9 37	9 27	9 14	8 57
4 30	8 56	9 11	9 23	9 34	9 43	9 51	9 56	10 0	10 0	9 56	9 50	9 41	9 31	9 18	9 1
5 0	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 37	9 20
5 30	9 37	9 52	10 4	10 15	10 24	10 32	10 37	10 41	10 41	10 37	10 31	10 22	10 12	9 59	9 42
6 0	9 55	10 10	10 22	10 33	10 42	10 50	10 55	10 59	10 59	10 55	10 49	10 40	10 30	10 17	10 0
6 30	10 12	10 27	10 39	10 50	10 59	11 7	11 12	10 16	10 16	11 12	11 6	10 57	10 47	10 34	10 17
7 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
7 30	10 20	10 35	10 47	10 58	11 7	11 15	11 20	11 24	11 24	11 20	11 14	11 5	10 55	10 42	10 25
8 0	10 22	10 37	10 49	11 0	11 9	11 17	11 22	11 26	11 26	11 22	11 16	11 7	10 57	10 44	10 27
8 30	10 24	10 39	10 51	11 2	11 11	11 19	11 24	11 28	11 28	11 24	11 18	11 9	10 59	10 46	10 29
9 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
9 30	10 10	10 25	10 37	10 48	10 57	11 5	11 10	11 14	11 14	11 10	11 4	10 55	10 45	10 32	19 15
10 0	10 0	10 15	10 27	10 38	10 47	10 55	11 0	11 4	11 4	11 0	10 54	10 45	10 35	10 22	10 5
10 30	9 53	10 8	10 20	10 31	10 40	10 48	10 53	10 57	10 57	10 53	10 47	10 38	10 28	10 15	9 58
11 0	9 45	10 0	10 12	10 23	10 32	10 40	10 45	10 49	10 49	10 45	10 39	10 30	10 20	10 7	9 50
11 30	9 36	9 51	10 3	10 14	10 23	10 31	10 36	10 40	10 40	10 36	10 30	10 21	10 11	9 58	9 41

TABLE V.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 30	9 16	9 4	8 53	8 44	8 36	8 31	8 27	8 27	8 31	8 37	8 46	8 56	9 9	9 26
0 30	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
1 0	9 14	8 59	8 47	8 36	8 27	8 19	8 14	8 10	8 10	8 14	8 20	8 29	8 39	8 52	9 9
1 30	9 7	8 52	8 40	8 29	8 20	8 12	8 7	8 3	8 3	8 7	8 13	8 22	8 32	8 45	9 2
2 0	9 0	8 45	8 33	8 22	8 13	8 5	8 0	7 56	7 56	8 0	8 6	8 15	8 25	8 38	8 55
2 30	8 55	8 40	8 28	8 17	8 8	8 0	7 55	7 51	7 51	7 55	8 1	8 10	8 20	8 33	8 50
3 0	8 54	8 39	8 27	8 1	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
3 30	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
4 0	8 58	8 43	8 31	8 20	8 11	8 3	7 58	7 54	7 54	7 58	8 4	8 13	8 23	8 36	8 53
4 30	9 2	8 47	8 35	8 24	8 15	8 7	8 2	7 58	7 58	8 2	8 8	8 17	8 27	8 40	8 57
5 0	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
5 30	9 43	9 28	9 16	9 5	8 56	8 48	8 43	8 39	8 39	8 43	8 49	8 58	9 8	9 21	9 38
6 0	10 1	9 46	9 34	9 23	9 14	9 6	9 1	8 57	8 57	9 1	9 7	9 16	9 26	9 39	9 56
6 30	10 18	10 3	9 51	9 40	9 31	9 23	9 18	9 14	9 14	9 18	9 24	9 33	9 43	9 56	10 13
7 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
7 30	10 26	10 11	9 59	9 48	9 39	9 31	9 26	9 22	9 22	9 26	9 32	9 41	9 51	10 4	10 21
8 0	10 28	10 13	10 1	9 50	9 41	9 33	9 28	9 24	9 24	9 28	9 34	9 43	9 53	10 6	10 23
8 30	10 30	10 15	10 3	9 52	9 43	9 35	9 30	9 26	9 26	9 30	9 36	9 45	9 55	10 8	10 25
9 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
9 30	10 16	10 1	9 49	9 38	9 29	9 21	9 16	9 12	9 12	9 16	9 22	9 31	9 41	9 54	10 11
10 0	10 6	9 51	9 39	9 28	9 19	9 11	9 6	9 2	9 2	9 6	9 12	9 21	9 31	9 44	10 1
10 30	9 59	9 44	9 32	9 21	9 12	9 4	8 59	8 55	8 55	8 59	9 5	9 14	9 24	9 37	9 54
11 0	9 51	9 36	9 24	9 13	9 4	8 56	8 51	8 47	8 47	8 51	8 57	9 6	9 16	9 29	9 46
11 30	9 42	9 27	9 15	9 4	8 55	8 47	8 42	8 38	8 38	8 42	8 48	8 57	9 7	9 20	9 37

TABLE IV.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	11 43	11 59	12 15	12 33	12 50	13 03	13 17	13 20	13 19	13 14	13 07	12 57	12 45	12 32	12 18
0 30	11 37	11 53	12 09	12 27	12 44	12 57	13 11	13 14	13 13	13 08	13 01	12 51	12 39	12 26	12 12
1 0	11 31	11 47	12 03	12 21	12 38	12 51	13 05	13 08	13 07	13 02	12 55	12 45	12 33	12 20	12 06
1 30	11 25	11 41	11 57	12 15	12 32	12 45	12 59	13 02	13 01	12 56	12 49	12 39	12 27	12 14	12 00
2 0	11 19	11 35	11 51	12 09	12 26	12 39	12 53	12 56	12 55	12 50	12 43	12 33	12 21	12 08	11 54
2 30	11 14	11 30	11 46	12 04	12 21	12 34	12 48	12 51	12 50	12 45	12 38	12 28	12 16	12 03	11 49
3 0	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
3 30	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
4 0	11 16	11 32	11 48	12 06	12 23	12 36	12 50	12 53	12 52	12 47	12 40	12 30	12 18	12 05	11 51
4 30	11 24	11 40	11 56	12 14	12 31	12 44	12 58	13 01	13 00	12 55	12 48	12 38	12 26	12 13	11 59
5 0	11 33	11 49	12 05	12 23	12 40	12 53	13 07	13 10	13 09	13 04	12 57	12 47	12 35	12 22	12 08
5 30	11 41	11 57	12 13	12 31	12 48	13 01	13 15	13 18	13 17	13 12	13 05	12 55	12 43	12 30	12 16
6 0	11 49	12 05	12 21	12 39	12 56	13 09	13 23	13 26	13 25	13 20	13 13	13 03	12 51	12 38	12 24
6 30	11 54	12 10	12 26	12 44	13 01	13 14	13 28	13 31	13 30	13 25	13 18	13 08	12 56	12 43	12 29
7 0	12 01	12 17	12 33	12 51	13 08	13 21	13 35	13 38	13 37	13 32	13 25	13 15	13 03	12 50	12 36
7 30	12 07	12 23	12 39	12 57	13 14	13 27	13 41	13 44	13 43	13 38	13 31	13 21	13 09	12 56	12 42
8 0	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
8 30	12 15	12 31	12 47	13 05	13 22	13 35	13 49	13 52	13 51	13 46	13 39	13 29	13 17	13 04	12 50
9 0	12 14	12 30	12 46	13 04	13 21	13 34	13 48	13 57	13 50	13 45	13 38	13 28	13 16	13 03	12 49
9 30	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
10 0	12 08	12 24	12 40	12 58	13 15	13 28	13 42	13 45	13 44	13 39	13 32	13 22	13 10	12 57	12 43
10 30	12 02	12 18	12 34	12 52	13 09	13 22	13 36	13 39	13 38	13 33	13 26	13 16	13 04	12 51	12 37
11 0	11 55	12 11	12 27	12 45	13 02	13 15	13 29	13 32	13 31	13 26	13 19	13 09	12 57	12 44	12 30
11 30	11 47	12 03	12 19	12 37	12 54	13 07	13 21	13 24	13 23	13 18	13 11	13 01	12 49	12 36	12 22

TABLE V.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	12 27	12 11	11 55	11 37	11 20	11 07	10 53	10 50	10 51	10 56	11 03	11 13	11 25	11 38	11 52
0 30	12 21	12 05	11 49	11 31	11 14	11 01	10 47	10 44	10 45	10 50	10 57	11 07	11 19	11 32	11 46
1 0	12 15	11 59	11 43	11 25	11 08	10 55	10 41	10 38	10 39	10 44	10 51	11 0[illegible]	11 13	11 26	11 40
1 30	12 09	11 53	11 37	11 19	11 02	10 49	10 35	10 32	10 33	10 38	10 45	10 55	11 07	11 20	11 34
2 0	12 03	11 47	11 31	11 13	10 56	10 43	10 29	10 26	10 27	10 32	10 39	10 49	11 01	11 14	11 28
2 30	11 58	11 42	11 26	11 08	10 51	10 38	10 24	10 21	10 22	10 27	10 34	10 44	10 56	11 09	11 23
3 0	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
3 30	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
4 0	12 00	11 44	11 28	11 10	10 53	10 40	10 26	10 23	10 24	10 29	10 36	10 46	10 58	11 11	11 25
4 30	12 08	11 52	11 36	11 18	11 01	10 48	10 34	10 31	10 32	10 37	10 44	10 54	11 06	11 19	11 33
5 0	12 17	12 01	11 45	11 27	11 10	10 57	10 43	10 40	10 41	10 46	10 53	11 03	11 15	11 28	11 42
5 30	12 25	12 09	11 53	11 35	11 18	11 05	10 51	10 48	10 49	10 54	11 01	11 11	11 23	11 36	11 50
6 0	12 33	12 17	12 01	11 43	11 26	11 13	10 59	10 56	10 57	11 02	11 09	11 19	11 31	11 44	11 58
6 30	12 38	12 22	12 06	11 48	11 31	11 18	11 04	11 01	11 02	11 07	11 14	11 24	11 36	11 49	12 03
7 0	12 45	12 29	12 13	11 55	11 38	11 25	11 11	11 08	11 09	11 14	11 21	11 31	11 43	11 56	12 10
7 30	12 51	12 35	12 19	12 01	11 44	11 31	11 17	11 14	11 15	11 20	11 27	11 37	11 49	12 02	12 16
8 0	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
8 30	12 59	12 43	12 27	12 09	11 52	11 39	11 25	11 22	11 23	11 28	11 35	11 45	11 57	12 10	12 24
9 0	12 58	12 42	12 26	12 08	11 51	11 38	11 24	11 21	11 22	11 27	11 34	11 44	11 56	12 09	12 23
9 30	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
10 0	12 52	12 36	12 20	12 02	11 45	11 32	11 18	11 15	11 16	11 21	11 28	11 38	11 50	12 03	12 17
10 30	12 46	12 30	12 14	11 56	11 39	11 26	11 12	11 09	11 10	11 15	11 22	11 32	11 44	11 57	12 11
11 0	12 39	12 23	12 07	11 49	11 32	11 19	11 05	11 02	11 03	11 08	11 15	11 25	11 37	11 50	12 04
11 30	12 31	12 15	11 59	11 41	11 24	11 11	10 57	10 54	10 55	11 00	11 07	11 17	11 29	11 42	11 56

TABLE IV.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After.						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	12 42	12 55	13 5	13 18	13 28	13 38	13 41	13 45	13 46	13 44	13 40	13 34	13 24	13 14	13 2
0 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
1 0	12 29	12 42	12 52	13 5	13 15	13 25	13 28	13 32	13 33	13 31	13 27	13 21	13 11	13 1	12 49
1 30	12 23	12 36	12 46	12 59	13 9	13 19	13 22	13 26	13 27	13 25	13 21	13 15	13 5	12 55	12 43
2 0	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
2 30	12 9	12 22	12 32	12 45	12 55	13 5	13 8	13 12	13 13	13 11	13 7	13 1	12 51	12 41	12 29
3 0	12 3	12 16	12 26	12 39	12 49	12 59	13 2	13 6	13 7	13 5	13 1	12 55	12 45	12 35	12 23
3 30	11 58	12 11	12 21	12 34	12 44	12 54	12 57	13 1	13 2	13 0	12 56	12 50	12 40	12 30	12 18
4 0	11 57	12 10	12 20	12 33	12 43	12 53	12 56	13 0	13 1	12 59	12 55	12 49	12 39	12 29	12 17
4 30	12 0	12 13	12 23	12 36	12 46	12 56	12 59	13 3	13 4	13 2	12 58	12 52	12 42	12 32	12 20
5 0	12 8	12 21	12 31	12 44	12 54	13 4	13 7	13 11	13 12	13 10	13 6	13 0	12 50	12 40	12 28
5 30	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
6 0	12 25	12 38	12 48	13 1	13 11	13 21	13 24	13 28	13 29	13 27	13 23	13 17	13 7	12 57	12 45
6 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
7 0	12 45	12 58	13 8	13 21	13 31	13 41	13 44	13 48	13 49	13 47	13 43	13 37	13 27	13 17	13 5
7 30	12 55	13 8	13 18	13 31	13 41	13 51	13 54	13 58	13 59	13 57	13 53	13 47	13 37	13 27	13 15
8 0	13 3	13 16	13 26	13 39	13 49	13 59	14 2	14 6	14 7	14 5	14 1	13 55	13 45	13 35	13 23
8 30	13 8	13 21	13 31	13 44	13 54	14 4	14 7	14 11	14 12	14 10	14 6	14 0	13 50	13 40	13 28
9 0	13 10	12 23	13 33	13 46	13 56	14 6	14 9	14 13	14 14	14 12	14 8	14 2	13 52	13 42	13 30
9 30	13 9	13 22	13 32	13 45	13 55	14 5	14 8	14 12	14 13	14 11	14 7	14 1	13 51	13 41	13 29
10 0	13 5	13 18	13 28	13 41	13 51	14 1	14 4	14 8	14 9	14 7	14 3	13 57	13 47	13 37	13 25
10 30	12 59	13 12	13 22	13 35	13 45	13 55	13 58	14 2	14 3	14 1	13 57	13 51	13 41	13 31	13 19
11 0	12 53	13 6	13 16	13 29	13 39	13 49	13 52	13 56	13 57	13 55	13 51	13 45	13 35	13 25	13 13
11 30	12 46	12 59	13 9	13 22	13 32	13 42	13 45	13 49	13 50	13 48	13 44	13 38	13 28	13 18	13 6

TABLE V.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	13 10	12 57	12 47	12 34	12 24	12 14	12 11	12 7	12 6	12 8	12 12	12 18	12 28	12 38	12 50
0 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
1 0	12 57	12 44	12 34	12 21	12 11	12 1	11 58	11 54	11 53	11 55	11 59	12 5	12 15	12 25	12 37
1 30	12 51	13 38	12 28	12 15	12 5	11 55	11 52	11 48	11 47	11 49	11 53	11 59	12 9	12 19	12 31
2 0	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 35	11 41	11 45	11 51	12 1	12 11	12 23
2 30	12 37	12 24	12 14	12 1	11 51	11 41	11 38	11 34	11 33	11 35	11 39	11 45	11 55	12 5	12 17
3 0	12 31	12 18	12 8	11 55	11 45	11 35	11 32	11 28	11 27	11 29	11 33	11 39	11 49	11 59	12 11
3 30	12 26	12 13	12 3	11 50	11 40	11 30	11 27	11 23	11 22	11 24	11 28	11 34	11 44	11 54	12 6
4 0	12 25	12 12	12 2	11 49	11 39	11 29	11 26	11 22	11 21	11 23	11 27	11 33	11 43	11 53	12 5
4 30	12 28	12 15	12 5	11 52	11 42	11 32	11 29	11 25	11 24	11 26	11 30	11 36	11 46	11 56	12 8
5 0	12 36	12 23	12 13	12 0	11 50	11 40	11 37	11 33	11 32	11 34	11 38	11 44	11 54	12 4	12 16
5 30	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
6 0	12 53	12 40	12 30	12 17	12 7	11 57	11 54	11 50	11 49	11 51	11 55	12 1	12 11	12 21	12 33
6 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
7 0	13 13	13 0	12 50	12 37	12 27	12 17	12 14	12 10	12 9	12 11	12 15	12 21	12 31	12 41	12 53
7 30	13 23	13 10	13 0	12 47	12 37	12 27	12 24	12 20	12 19	12 21	12 25	12 31	12 41	12 51	13 3
8 0	13 31	13 18	13 8	12 55	12 45	12 35	12 32	12 28	12 27	12 29	12 33	12 39	12 49	12 59	13 11
8 30	13 36	12 23	13 13	13 0	12 50	12 40	12 37	12 33	12 32	12 34	12 38	12 44	12 54	13 4	13 16
9 0	13 38	13 25	13 15	13 2	12 52	12 42	12 39	12 35	12 34	12 36	12 40	12 46	12 56	13 6	13 18
9 30	13 37	13 24	13 14	13 1	12 51	12 41	12 38	12 34	12 33	12 35	12 39	12 45	12 55	13 5	13 17
10 0	13 33	13 20	13 10	12 57	12 47	12 37	12 34	12 30	12 29	12 31	12 35	12 41	12 51	13 1	13 13
10 30	13 27	13 14	13 4	12 51	12 41	12 31	12 28	12 24	12 23	12 25	12 29	12 35	12 45	12 55	13 7
11 0	13 21	13 8	12 58	12 45	12 35	12 25	12 22	12 18	12 17	12 19	12 23	12 29	12 39	12 49	13 1
11 30	13 14	13 1	12 51	12 38	12 28	12 18	12 15	12 11	12 10	12 12	12 16	12 22	12 32	12 42	12 54

TABLE IV.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	3 45	3 21	2 51	2 2	1 32	1 13	1 26	1 44	2 2	2 21	2 42	2 57	3 15	3 33	3 45
0 30	3 38	3 14	2 44	1 55	1 25	1 6	1 19	1 37	1 55	2 14	2 35	2 50	3 8	3 26	3 38
1 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
1 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
2 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
2 30	3 18	2 54	2 24	1 35	1 5	0 46	0 59	1 17	1 35	1 54	2 15	2 20	2 48	3 6	3 18
3 0	3 16	2 52	2 22	1 33	1 3	0 44	0 57	1 15	1 33	1 52	2 13	2 28	2 46	3 4	3 16
3 30	3 17	2 53	2 23	1 34	1 4	0 45	0 58	1 16	1 34	1 53	2 14	2 29	2 47	3 5	3 17
4 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
4 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
5 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
5 30	3 41	3 17	2 47	1 58	1 28	1 9	1 22	1 40	1 58	2 17	2 38	2 53	3 11	3 29	3 41
6 0	3 52	3 28	2 58	2 9	1 39	1 20	1 33	1 51	2 9	2 28	2 49	3 4	3 22	3 40	3 52
6 30	4 1	3 37	3 7	2 18	1 48	1 29	1 42	2 0	2 18	2 37	2 58	3 13	3 31	3 49	4 1
7 0	4 8	3 44	3 14	2 25	1 55	1 36	1 49	2 7	2 25	2 44	3 5	3 20	3 38	3 56	4 8
7 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
8 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
8 30	4 19	3 55	3 25	2 36	2 6	1 47	2 0	2 18	2 36	2 55	3 16	3 31	3 49	4 7	4 19
9 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
9 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
10 0	4 10	3 46	3 16	2 27	1 57	1 38	1 51	2 9	2 27	2 46	3 7	3 22	3 40	3 58	4 10
10 30	4 6	3 42	3 12	2 23	1 53	1 34	1 47	2 5	2 23	2 42	3 3	3 18	3 36	3 54	4 6
11 0	4 0	3 36	3 6	2 17	1 47	1 28	1 41	1 59	2 17	2 36	2 57	3 12	3 30	3 48	4 0
11 30	3 54	3 30	3 0	2 11	1 41	1 22	1 35	1 53	2 11	2 30	2 51	3 6	3 24	3 42	3 54

TABLE V.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	3 45	4 9	4 39	5 28	5 58	6 17	6 4	5 46	5 28	5 9	4 48	4 33	4 15	3 57	3 45
0 30	3 38	4 2	4 32	5 21	5 51	6 10	5 57	5 39	5 21	5 2	4 41	4 26	4 8	3 50	3 38
1 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
1 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
2 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
2 30	3 18	3 42	4 12	5 1	5 31	5 50	5 37	5 19	5 1	4 42	4 21	4 6	3 48	3 30	3 18
3 0	3 16	3 40	4 10	4 59	5 29	5 48	5 35	5 17	4 59	4 40	4 19	4 4	3 46	3 28	3 16
3 30	3 17	3 41	4 11	5 0	5 30	5 49	5 36	5 18	5 0	4 41	4 20	4 5	3 47	3 29	3 17
4 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
4 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
5 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
5 30	3 41	4 5	4 35	5 24	5 54	6 13	6 0	5 42	5 24	5 5	4 44	4 29	4 11	3 53	3 41
6 0	3 52	4 16	4 46	5 35	6 5	6 24	6 11	5 53	5 35	5 16	4 55	4 40	4 22	4 4	3 52
6 30	4 1	4 25	4 55	5 44	6 14	6 33	6 20	6 2	5 44	5 25	5 4	4 49	4 31	4 13	4 1
7 0	4 8	4 32	5 2	5 51	6 21	6 40	6 27	6 9	5 51	5 32	5 11	4 56	4 38	4 20	4 8
7 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
8 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
8 30	4 19	4 43	5 13	6 2	6 32	6 51	6 38	6 20	6 2	5 43	5 22	5 7	4 49	4 31	4 19
9 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
9 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
10 0	4 10	4 34	5 4	5 53	6 23	6 42	6 29	6 11	5 53	5 34	5 13	4 58	4 40	4 22	4 10
10 30	4 6	4 30	5 0	5 49	6 19	6 38	6 25	6 7	5 49	5 30	5 9	4 54	4 36	4 18	4 6
11 0	4 0	4 24	4 54	5 43	6 13	6 32	6 19	6 1	5 43	5 24	5 3	4 48	4 30	4 12	4 0
11 30	3 54	4 18	4 48	5 37	6 7	6 26	6 13	5 55	5 37	5 18	4 57	4 42	4 24	4 6	3 54

If we disregard the daily inequality, the column headed San Francisco in Table II would give us, as in the examples on the Atlantic coast, the means of determining the time of high water.

Example V.—Required, the time of high water at North Beach, San Francisco, California, on the 7th of February, 1853.

1st. The time of the moon's transit at Greenwich, from the Nautical Almanac, is 11*h.* 41*m.*; the longitude of San Francisco 8*h.* 10*m.*, requiring a correction of 16*m.* to the time of transit for San Francisco, which is thus found to be 11*h.* 57*m.*

2d. The moon's declination is south, and at the time of transit about two days after the greatest. Entering Table IV we find 12*h.* (or 0*h.*) of transit, the nearest number to 11*h.* 57*m.* which the table gives; and following the line horizontally until we come to two days after the greatest declination, we find 13*h.* 14*m.*

To 11*h.* 57*m.*, time of transit of the moon February 7, San Francisco, add 13*h.* 14*m.*, from column 0*h.* transit, and two days after greatest declination; the sum, 25*h.* 11*m.*, or 1*h.* 11*m.*, February 8, is the time of high water, corresponding to the transit which we took of February 7. If we desire the tide of February 7 we must go back to the moon's transit of the 6th. The example was purposely assumed to show this case.

	11*h*	01*m.*,	time of transit February 6, 1853.
	13	31	number for 11*h.* transit, and one day from greatest declination.
Sum	24	32	time of high water 0*h.* 32*m.* a m., February 7.

The height of high water.—The height of high water is obtained in a similar manner by the use of Table VI and Table VII, entering these in the same way with the time of transit and days from the greatest declination. Table VI is for south declination, and Table VII for north.

TABLE VI.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
1	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
2	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
3	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
4	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
5	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
6	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
7	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
8	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
9	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
10	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
11	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5

TABLE VII.—KEY WEST.

NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.

Time of moon's transit.	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
1	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
2	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
3	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
4	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
5	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
6	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
7	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
8	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
9	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
10	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
11	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8

TABLE VI.—SAN DIEGO.

SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.

Time of moon's transit.	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	5	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
1	4.6	4.4	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.2	4.4	4.7	5.0	5.4	5.7
2	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
3	4.1	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.9	4.2	4.5	4.9	5.2
4	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
5	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
6	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
7	3.7	3.5	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.5	3.8	4.1	4.5	4.8
8	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
9	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
10	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
11	4.8	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.9	5.2	5.6	5.9

TABLE VII.—SAN DIEGO.

NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.

Time of moon's transit.	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
1	5.6	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.5	5.2	4.8	4.5
2	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
3	5.1	5.3	5.5	5.6	5.7	5.7	5.7	5.7	5.6	5.5	5.3	5.0	4.7	4.3	4.0
4	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
5	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
6	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
7	4.7	4.9	5.1	5.2	5.3	5.3	5.3	5.3	5.2	5.1	4.9	4.6	4.3	3.9	3.6
8	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
9	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
10	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
11	5.8	6.0	6.2	6.3	6.4	6.4	6.4	6.4	6.3	6.2	6.0	5.7	5.4	5.0	4.7

TABLE VI.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5
1	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
2	4.6	4.5	4.3	4.1	4.1	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.1	5.3
3	4 5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
4	4.3	4.2	4.0	3.8	3.8	3.7	3.8	3.8	3.9	4.0	4.2	4.3	4.5	4.8	5.0
5	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
6	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
7	4.2	4.1	3.9	3.7	3.7	3.6	3.7	3.7	3.8	3.9	4.1	4.2	4.4	4.7	4.9
8	4.4	4.3	4.1	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3	4.4	4.6	4.9	5.1
9	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
10	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
11	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5

TABLE VII.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7
1	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
2	5.2	5.3	5.5	5.7	5.7	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.0	4.7	4.5
3	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
4	4.9	5.0	5.2	5.4	5.4	5.5	5.4	5.4	5.3	5.2	5.0	4.9	4.7	4.4	4.2
5	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
6	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
7	4.8	4.9	5.1	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4.9	4.8	4.6	4.3	4.1
8	5.0	5.1	5.3	5.5	5.5	5.6	5.5	5.5	5.4	5.3	5.1	5.0	4.8	4.5	4.3
9	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
10	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
11	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7

TABLE VI.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	8.0	8.3	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.3	8.1	7.7	7.4	7.0
1	8.0	8.2	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.2	8.1	7.7	7.4	7.0
2	7.8	8.1	8.2	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.1	7.9	7.5	7.2	6.8
3	7.5	7.8	7.9	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.2	6.9	6.5
4	7.1	7.4	7.5	7.7	7.7	7.7	7.7	7.7	7.6	7.5	7.4	7.2	6.8	6.5	6.1
5	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.5	6.1	5.7
6	6.5	6.8	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6.6	6.3	5.9	5.5
7	6.7	7.0	7.1	7.2	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.4	6.1	5.7
8	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.4	6.0
9	7.5	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.3	6.9	6.5
10	7.9	8.2	8.4	8.5	8.5	8.5	8.5	8.5	8.4	8.3	8.2	8.0	7.7	7.3	6.9
11	8.1	8.4	8.6	8.7	8.7	8.7	8.7	8.7	8.6	8.5	8.4	8.2	7.9	7.5	7.1

TABLE VII.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
1	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
2	7.2	6.9	6.8	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.9	7.1	7.5	7.8	8.2
3	6.9	6.6	6.5	6.3	6.3	6.3	6.3	6.3	6.4	6.5	6.6	6.8	7.2	7.5	7.9
4	6.5	6.2	6.1	5.9	5.9	5.9	5.9	5.9	6.0	6.1	6.2	6.4	6.7	7.1	7.5
5	6.1	5.9	5.7	5.6	5.5	5.5	5.6	5.6	5.7	5.7	5.9	6.0	6.4	6.7	7.1
6	5.9	5.7	5.5	5.4	5.3	5.3	5.3	5.4	5.5	5.5	5.7	5.9	6.2	6.5	6.9
7	6.1	5.8	5.6	5.5	5.5	5.5	5.5	5.5	5.6	5.7	5.8	6.0	6.3	6.7	7.1
8	6.4	6.2	6.0	5.9	5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.3	6.7	7.0	7.4
9	6.9	6.7	6.5	6.4	6.3	6.3	6.3	6.4	6.4	6.5	6.7	6.8	7.2	7.5	7.9
10	7.3	7.1	6.9	6.8	6.7	6.7	6.7	6.8	6.9	6.9	7.0	7.2	7.6	7.9	8.3
11	7.5	7.2	7.1	7.0	6.9	6.9	6.9	6.9	7.0	7.1	7.2	7.4	7.8	8.1	8.5

TABLE VI.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
1	6.7	6.4	6.0	6.2	6.5	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.7	7.8	8.0
2	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
3	6.3	6.0	5.6	5.8	6.1	6.6	6.9	7.1	7.2	7.2	7.2	7.2	7.3	7.4	7.6
4	6.0	5.7	5.3	5.5	5.8	6.3	6.6	6.8	6.9	6.9	6.9	6.9	7.0	7.1	7.3
5	5.9	5.6	5.2	5.4	5.7	6.2	6.5	6.7	6.8	6.8	6.8	6.8	6.9	7.0	7.2
6	6.1	5.8	5.4	5.6	5.9	6.4	6.7	6.9	7.0	7.0	7.0	7.0	7.1	7.2	7.4
7	6.4	6.1	5.7	5.9	6.2	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.4	7.5	7.7
8	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
9	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
10	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
11	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9

TABLE VII.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
1	7.7	8.0	8.4	8.2	7.9	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.7	6.6	6.4
2	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
3	7.3	7.6	8.0	7.8	7.5	7.0	6.7	6.5	6.4	6.4	6.4	6.4	6.3	6.2	6.0
4	7.0	7.3	7.7	7.5	7.2	6.7	6.4	6.2	6.1	6.1	6.1	6.1	6.0	5.9	5.7
5	6.9	7.2	7.6	7.4	7.1	6.6	6.3	6.1	6.0	6.0	6.0	6.0	5.9	5.8	5.6
6	7.1	7.4	7.8	7.6	7.3	6.8	6.5	6.3	6.2	6.2	6.2	6.2	6.1	6.0	5.8
7	7.4	7.7	8.1	7.9	7.6	7.1	6.8	6.6	6.5	6.5	6.5	6.5	6.4	6.3	6.1
8	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
9	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
10	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
11	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 1.2 foot from the numbers in the tables from San Diego to Astoria, 1.7 foot for Nee-ah harbor, 2.3 for Port Townshend, and 2.7 for Semiahmoo and Steilacoom.

Example VI.—In Example V, to obtain the height of tide on February 7, the declination being south, we enter Table VI for San Francisco, with 0*h.* of transit, and two days after greatest declination, and find that the tide will be 4.5 feet above the mean of the lowest low water, or that 4.5 feet are to be added to the soundings of a chart reduced to the mean of the lowest low waters of each day. If the soundings of the chart are given for mean low water, then 1.2 feet ought to be subtracted from the Table VI and VII; thus, in this example, it would be 3.3 feet.

The approximate time of the successive low and high waters of the day will be found by adding the numbers in Table VIII to the time of the first high water already determined. The table gives the numbers for the different days from the greatest declination.

Tables containing numbers to be added to the time of high water found from Tables IV and V, to obtain the successive high and low waters.

TABLE VIII.—KEY WEST.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Large.)	High water. (Small.)	Low water. (Small.)	Low water. (Small.)	High water. (Large.)	Low water. (Large.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 22	12 10	17 38	5 36	12 33	17 46	7	Before.
	6	5 42	12 31	17 40	5 18	12 18	17 50	6	
	5	6 05	12 55	17 41	4 58	12 03	17 56	5	
	4	6 24	13 17	17 44	4 35	11 44	17 59	4	
	3	6 39	13 28	17 39	4 11	11 18	17 58	3	
	2	7 02	13 52	17 40	3 50	10 58	17 58	2	
	1	7 13	14 01	17 39	3 39	10 46	17 56	1	
	0	7 18	14 10	17 42	3 37	10 46	17 59	0	
After.	1	7 12	14 10	17 48	3 44	10 46	17 52	1	After.
	2	6 57	13 58	17 51	3 57	10 54	17 47	2	
	3	6 39	13 41	17 53	4 21	11 19	17 48	3	
	4	6 15	13 18	17 53	4 43	11 38	17 45	4	
	5	5 57	12 59	17 53	5 09	12 03	17 44	5	
	6	5 32	12 36	17 54	5 26	12 22	17 46	6	
	7	5 13	12 16	17 53	5 40	12 36	17 46	7	

TABLE VIII.—SAN DIEGO.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 44	12 28	18 44	6 16	12 16	18 00	7	Before.
	6	5 18	11 58	18 40	6 42	12 46	18 04	6	
	5	5 00	11 34	18 34	7 00	13 10	18 10	5	
	4	4 47	11 12	18 25	7 13	13 32	18 19	4	
	3	4 34	10 54	18 20	7 26	13 50	18 24	3	
	2	4 24	10 38	18 14	7 36	14 06	18 30	2	
	1	4 17	10 28	18 11	7 43	14 16	18 33	1	
	0	4 12	10 20	18 08	7 48	14 24	18 36	0	
After.	1	4 14	10 20	18 06	7 46	14 24	18 38	1	After.
	2	4 24	10 28	18 04	7 36	14 16	18 40	2	
	3	4 38	10 40	18 02	7 22	14 04	18 42	3	
	4	5 01	10 58	17 57	6 59	13 46	18 47	4	
	5	5 25	11 18	17 53	6 35	13 26	18 51	5	
	6	5 49	11 44	17 55	6 11	13 00	18 49	6	
	7	6 18	12 18	18 00	5 42	12 26	18 44	7	

TABLE VIII.—SAN FRANCISCO.

	Days from moon's greatest declination.	SOUTH DECLINATION			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	5 58	13 14	18 58	5 44	11 46	17 44	7	Before.
	6	5 36	12 42	18 48	6 06	12 18	17 54	6	
	5	5 14	12 10	18 38	6 28	12 50	18 04	5	
	4	4 55	11 34	18 21	6 47	13 26	18 21	4	
	3	4 37	11 00	18 05	7 05	14 00	18 37	3	
	2	4 24	10 34	17 52	7 18	14 26	18 50	2	
	1	4 12	10 06	17 36	7 30	14 54	19 06	1	
	0	4 12	10 00	17 30	7 30	15 00	19 12	0	
After.	1	4 17	10 02	17 27	7 25	14 58	19 15	1	After.
	2	4 27	10 12	17 27	7 15	14 48	19 15	2	
	3	4 41	10 26	17 27	7 01	14 34	19 15	3	
	4	4 56	10 46	17 32	6 46	14 14	19 10	4	
	5	5 14	11 10	17 38	6 28	13 50	19 04	5	
	6	5 36	11 36	17 42	6 06	13 24	19 00	6	
	7	5 57	12 04	17 49	5 45	12 56	18 53	7	

TABLE VIII.—ASTORIA.

	Days from moon's greatest declination.	SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 38	12 59	19 17	6 18	12 03	18 41	7	Before.
	6	6 14	12 33	19 15	6 42	12 29	18 43	6	
	5	5 55	12 13	19 14	7 01	12 49	18 44	5	
	4	5 34	11 47	19 09	7 22	13 15	18 49	4	
	3	5 20	11 27	19 03	7 36	13 35	18 55	3	
	2	5 09	11 07	18 54	7 47	13 55	19 04	2	
	1	5 05	11 01	18 52	7 51	14 01	19 06	1	
	0	5 03	10 53	18 46	7 53	14 09	19 12	0	
After.	1	5 05	10 51	18 42	7 51	14 11	19 16	1	After.
	2	5 11	10 55	18 40	7 45	14 07	19 18	2	
	3	5 18	11 03	18 41	7 38	13 59	19 17	3	
	4	5 32	11 15	18 39	7 24	13 47	19 19	4	
	5	5 50	11 35	18 41	7 06	13 27	19 17	5	
	6	6 11	11 55	18 40	6 45	13 07	19 18	6	
	7	6 35	12 19	18 40	6 21	12 43	19 18	7	

TABLE VIII.—PORT TOWNSHEND.

Days from moon's greatest declination.		SOUTH DECLINATION.			NORTH DECLINATION.			Days from moon's greatest declination.	
		Low water.	High water.	Low water.	Low water.	High water.	Low water.		
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 05	12 26	18 05	5 39	12 26	18 31	7	Before.
	6	6 38	13 14	18 20	5 06	11 38	18 16	6	
	5	7 18	14 14	18 40	4 26	10 38	17 56	5	
	4	8 13	15 52	19 23	3 31	9 00	17 13	4	
	3	8 36	16 52	20 00	3 08	8 00	16 36	3	
	2	8 43	17 30	20 31	3 01	7 22	16 05	2	
	1	8 12	17 04	20 36	3 32	7 48	16 00	1	
	0	7 40	16 28	20 32	4 04	8 24	16 04	0	
After.	1	7 18	15 52	20 18	4 26	9 00	16 18	1	After.
	2	6 59	15 14	19 59	4 45	9 38	16 37	2	
	3	6 38	14 32	19 38	5 06	10 20	16 58	3	
	4	6 24	14 02	19 22	5 20	10 50	17 14	4	
	5	6 10	13 26	19 00	5 34	11 26	17 36	5	
	6	5 59	12 50	18 35	5 45	12 02	18 01	6	
	7	5 42	12 26	18 28	6 02	12 26	18 08	7	

The days from the greatest declination are written in the first and last columns of the table. The second, third, and fourth columns refer to south declination, and fifth, sixth, and seventh to north, and the reverse for Key West. The second column gives the number which is to be added, according to the declination, to the time of high water, obtained by means of Tables IV and V, to give the next low water, which is the small low water, *b*, of diagram I. The third contains the numbers to be added to the same to give the second or large high water, *c*, of diagram I. The fourth, the numbers to be added to the same to give the second or large low water, *d*, of diagram I. The succeeding columns give the numbers to be used in the same way for north declination to obtain the low water, *b*, (large,) of diagram II; the high water, *c*, (small,) and the low water, *d*, (small,) of the same diagram. The rise and fall of the same successive tides may be obtained by inspection from Table IX, in which the first column at the side contains the time of transit, and the successive columns the numbers corresponding to that time and to the number of days from greatest declination. The arrangement of this table is like that already given.

The numbers for the small ebb tide, *a b*, of diagram I, or *c d*, of diagram II, are first given; then those for small low and large high waters, *b c*, of diagram I, and *d e*, of diagram II; next, the large ebb tide, *c d*, of diagram I, or *a b*, of diagram II; and lastly, from the large low water to the small high water, *d e*, of diagram I, or *b c*, of diagram II.

TABLE IX.—KEY WEST.

Time of moon's transit.	SMALL EBB TIDE.															SMALL LOW TO LARGE HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	0
1	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	1
2	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	2
3	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	3
4	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	4
5	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	5
6	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	6
7	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	7
8	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	8
9	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	9
10	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	10
11	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	11

TABLE IX.—KEY WEST—Continued.

Time of moon's transit.	LARGE EBB TIDE.															LARGE LOW TO SMALL HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	0
1	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	1
2	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	2
3	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	3
4	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	4
5	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	5
6	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	6
7	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	7
8	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	8
9	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	9
10	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	10
11	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	11

TABLE IX.—SAN DIEGO.

Time of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	4.0	3.4	3.0	2.6	2.3	2.1	2.0	2.0	2.1	2.3	2.7	3.2	3.8	4.6	5.2	5.1	4.9	4.7	4.5	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.9	3.9	4.0	0
1	3.8	3.2	2.8	2.4	2.1	1.9	1.8	1.8	1.9	2.1	2.5	3.0	3.6	4.4	5.0	4.9	4.7	4.5	4.3	4.2	4.1	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.8	1
2	3.5	2.9	2.5	2.1	1.8	1.6	1.5	1.5	1.6	1.8	2.2	2.7	3.3	4.1	4.7	4.6	4.4	4.2	4.0	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4	3.4	3.5	2
3	3.0	2.4	2.0	1.6	1.3	1.1	1.0	1.0	1.1	1.3	1.7	2.2	2.8	3.6	4.2	4.1	3.9	3.7	3.5	3.4	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	3.0	3
4	2.2	1.6	1.2	0.8	0.5	0.3	0.2	0.2	0.3	0.5	0.9	1.4	2.0	2.8	3.4	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.2	4
5	1.7	1.1	0.7	0.3	0.0	–.2	–.3	–.3	–.2	0.0	0.4	0.9	1.5	2.3	2.9	2.8	2.6	2.4	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.7	5
6	1.8	1.2	0.8	0.4	0.1	–.1	–.2	–.2	–.1	0.1	0.5	1.0	1.6	2.4	3.0	2.9	2.7	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.8	6
7	2.3	1.7	1.3	0.9	0.6	0.4	0.3	0.3	0.4	0.6	1.0	1.5	2.1	2.9	3.5	3.4	3.2	3.0	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.3	7
8	2.9	2.3	1.9	1.5	1.2	1.0	0.9	0.9	1.0	1.2	1.6	2.1	2.7	3.5	4.1	4.0	3.8	3.6	3.4	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.9	8
9	3.7	3.1	2.7	2.3	2.0	1.8	1.7	1.7	1.8	2.0	2.4	2.9	3.5	4.3	4.9	4.8	4.6	4.4	4.2	4.1	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.6	3.6	3.7	9
10	4.2	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.3	2.5	2.9	3.4	4.0	4.8	5.4	5.3	5.1	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.2	10
11	4.3	3.7	3.3	2.9	2.6	2.4	2.3	2.3	2.4	2.6	3.0	3.5	4.1	4.9	5.5	5.4	5.2	5.0	4.8	4.7	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.3	11

From *a* to *b*.......................................Diagram I
From *c* to *d*.......................................Diagram II

From *b* to *c*.......................................Diagram I
From *d* to *e*.......................................Diagram II

TABLE IX.—SAN DIEGO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	5.2	5.8	6.2	6.6	6.9	7.1	7.2	7.2	7.1	6.9	6.5	6.0	5.4	4.6	4.0	4.1	4.3	4.5	4.7	4.8	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.2	0
1	5.0	5.6	6.0	6.4	6.7	6.9	7.0	7.0	6.9	6.7	6.3	5.8	5.2	4.4	3.8	3.9	4.1	4.3	4.5	4.6	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.0	1
2	4.7	5.3	5.7	6.1	6.4	6.6	6.7	6.7	6.6	6.4	6.0	5.5	4.9	4.1	3.5	3.6	3.8	4.0	4.2	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.7	2
3	4.2	4.8	5.2	5.6	5.9	6.1	6.2	6.2	6.1	5.9	5.5	5.0	4.4	3.6	3.0	3.1	3.3	3.5	3.7	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.2	3
4	3.4	4.0	4.4	4.8	5.1	5.3	5.4	5.4	5.3	5.1	4.7	4.2	3.6	2.8	2.2	2.3	2.5	2.7	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.4	4
5	2.9	3.5	3.9	4.3	4.6	4.8	4.9	4.9	4.8	4.6	4.2	3.7	3.1	2.3	1.7	1.8	2.0	2.2	2.4	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	2.9	5
6	3.0	3.6	4.0	4.4	4.7	4.9	5.0	5.0	4.9	4.7	4.3	3.8	3.2	2.4	1.8	1.9	2.1	2.3	2.5	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.0	6
7	3.5	4.1	4.5	4.9	5.2	5.4	5.5	5.5	5.4	5.2	4.8	4.3	3.7	2.9	2.3	2.4	2.6	2.8	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.5	7
8	4.1	4.7	5.1	5.5	5.8	6.0	6.1	6.1	6.0	5.8	5.4	4.9	4.3	3.5	2.9	3.0	3.2	3.4	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.1	8
9	4.9	5.5	5.9	6.3	6.6	6.8	6.9	6.9	6.8	6.6	6.2	5.7	5.1	4.3	3.7	3.8	4.0	4.2	4.4	4.5	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0	4.9	9
10	5.4	6.0	6.4	6.8	7.1	7.3	7.4	7.4	7.3	7.1	6.7	6.2	5.6	4.8	4.2	4.3	4.5	4,7	4.9	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.4	10
11	5.5	6.1	6.5	6.9	7.2	7.4	7.5	7.5	7.4	7.2	6.8	6.3	5.7	4.9	4.3	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.5	11

From *c* to *d*.......................................Diagram I
From *a* to *b*.......................................Diagram II

From *d* to *e*.......................................Diagram I
From *b* to *c*.......................................Diagram II

TABLE IX.—SAN FRANCISCO.

SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination.

Time of moon's transit.	Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4
1	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2
2	4.3	3.6	3.0	2.5	2.0	1.6	1.4	1.3	1.3	1.5	1.8	2.2	2.7	3.3	4.0
3	4.0	3.3	2.7	2.2	1.7	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3.7
4	3.6	2.9	2.3	1.8	1.3	0.9	0.7	0.6	0.6	0.8	1.1	1.5	2.0	2.6	3.3
5	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9
6	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9
7	3.4	2.7	2.1	1.6	1.1	0.7	0.5	0.4	0.4	0.6	0.9	1.3	1.8	2.4	3.1
8	3.8	3.1	2.5	2.0	1.5	1.1	0.9	0.8	0.8	1.0	1.3	1.7	2.2	2.8	3.5
9	4.1	3.4	2.8	2.3	1.8	1.4	1.2	1.1	1.1	1.3	1.6	2.0	2.5	3.1	3.8
10	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2
11	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4

From *a* to *b*..Diagram I
From *c* to *d*..Diagram II

FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination.

Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7	Time of moon's transit.
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	0
5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	1
4.8	4.5	4.2	4.1	3.6	3.3	3.0	2.8	2.7	2.6	2.7	2.7	2.9	3.0	3.1	2
4.5	4.2	3.9	3.8	3.3	3.0	2.7	2.5	2.4	2.3	2.4	2.4	2.6	2.7	2.8	3
4.1	3.8	3.5	3.4	2.9	2.6	2.3	2.1	2.0	1.9	2.0	2.0	2.2	2.3	2.4	4
3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	5
3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	6
3.9	3.6	3.3	3.2	2.7	2.4	2.1	1.9	1.8	1.7	1.8	1.8	2.0	2.1	2.2	7
4.3	4.0	3.7	3.6	3.1	2.8	2.5	2.3	2.2	2.1	2.2	2.2	2.4	2.5	2.6	8
4.6	4.3	4.0	3.9	3.4	3.1	2.8	2.6	2.5	2.4	2.5	2.5	2.7	2.8	2.9	9
5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	10
5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	11

From *b* to *c*..Diagram I
From *d* to *e*..Diagram II

TABLE IX.—SAN FRANCISCO—Continued.

LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination.

Time of moon's transit.	Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2
1	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0
2	3.5	4.2	4.8	5.3	5.8	6.2	6.4	6.5	6.5	6.3	6.0	5.6	5.1	4.5	3.8
3	3.2	3.9	4.5	5.0	5.5	5.9	6.1	6.2	6.2	6.0	5.7	5.3	4.8	4.2	3.5
4	2.8	3.5	4.1	4.6	5.1	5.5	5.7	5.8	5.8	5.6	5.3	4.9	4.4	3.8	3.1
5	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7
6	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7
7	2.6	3.3	3.9	4.4	4.9	5.3	5.5	5.6	5.6	5.4	5.1	4.7	4.2	3.6	2.9
8	3.0	3.7	4.3	4.8	5.3	5.7	5.9	6.0	6.0	5.8	5.5	5.1	4.6	4.0	3.3
9	3.3	4.0	4.6	5.1	5.6	6.0	6.2	6.3	6.3	6.1	5.8	5.4	4.9	4.3	3.6
10	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0
11	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2

From *c* to *d*..Diagram I
From *a* to *c*..Diagram II

FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination.

Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7	Time of moon's transit.
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.6	5.5	5.3	5.2	5.2	0
3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.5	5.3	5.1	5.0	5.0	1
3.0	3.3	3.6	3.7	4.2	4.5	4.8	5.0	5.1	5.2	5.1	5.1	4.9	4.8	4.8	2
2.7	3.0	3.3	3.4	3.9	4.2	4.5	4.7	4.8	4.9	4.8	4.8	4.6	4.5	4.5	3
2.3	2.6	2.9	3.0	3.5	3.8	4.1	4.3	4.4	4.5	4.4	4.4	4.2	4.1	4.1	4
1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	5
1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	6
2.1	2.4	2.7	2.8	3.3	3.6	3.9	4.1	4.2	4.3	4.2	4.2	4.0	3.9	3.9	7
2.5	2.8	3.1	3.2	3.7	4.0	4.3	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.3	8
2.8	3.1	3.4	3.5	4.0	4.3	4.6	4.8	4.9	5.0	4.9	4.9	4.7	4.6	4.6	9
3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	10
3.4	3.7	4.0	4.0	4.6	4.9	5.2	5.4	5.5	5.6	5.5	5.5	5.3	5.2	5.2	11

From *d* to *e*..Diagram I
From *b* to *c*..Diagram II

TABLE IX.—ASTORIA.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER. Days from moon's greatest declination. Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	7.4	6.7	6.0	5.4	5.0	4.6	4.5	4.5	4.6	4.7	5.1	5.5	6.2	6.9	7.8
1	7.5	6.8	6.1	5.5	5.1	4.7	4.6	4.6	4.7	4.8	5.2	5.6	6.3	7.0	7.9
2	7.2	6.5	5.8	5.2	4.8	4.4	4.3	4.3	4.4	4.5	4.9	5.3	6.0	6.7	7.6
3	6.6	5.9	5.2	4.6	4.2	3.8	3.7	3.7	3.8	3.9	4.3	4.7	5.4	6.1	7.0
4	5.9	5.2	4.5	3.9	3.5	3.1	3.0	3.0	3.1	3.2	3.6	4.0	4.7	5.4	6.3
5	5.2	4.5	3.8	3.2	2.8	2.4	2.3	2.3	2.4	2.5	2.9	3.3	4.0	4.7	5.6
6	4.8	4.1	3.4	2.8	2.4	2.0	1.9	1.9	2.0	2.1	2.5	2.9	3.6	4.3	5.2
7	5.0	4.3	3.6	3.0	2.6	2.2	2.1	2.1	2.2	2.3	2.7	2.1	3.8	4.5	5.4
8	5.5	4.8	4.1	3.5	3.1	2.7	2.6	2.6	2.7	2.8	3.2	3.6	4.3	5.0	5.9
9	6.3	5.6	4.9	4.3	3.9	3.5	3.4	3.4	3.5	3.6	4.0	4.4	5.1	5.8	6.7
10	7.0	6.3	5.6	5.0	4.6	4.2	4.1	4.1	4.2	4.3	4.7	5.1	5.8	6.5	7.4
11	7.3	6.6	6.9	5.3	4.9	4.5	4.4	4.4	4.5	4.6	5.0	5.4	6.1	6.8	7.7

From *a* to *b*..Diagram I
From *c* to *d*..Diagram II

FROM SMALL LOW WATER TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
8.0	7.8	7.5	7.2	6.8	6.4	6.3	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.4	0
8.1	7.9	7.6	7.3	6.9	6.5	6.4	6.3	6.2	6.3	6.3	6.4	6.4	6.4	6.5	1
7.8	7.6	7.3	7.0	6.6	6.2	6.1	6.0	5.9	6.0	6.0	6.1	6.1	6.1	6.2	2
7.2	7.0	6.7	6.4	6.0	5.6	5.5	5.4	5.3	5.4	5.4	5.5	5.5	5.5	5.6	3
6.5	6.3	6.0	5.7	5.3	4.9	4.8	4.7	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4
5.8	5.6	5.3	5.0	4.6	4.2	4.1	4.0	3.9	4.0	4.0	4.1	4.1	4.1	4.2	5
5.4	5.2	4.9	4.6	4.2	3.8	3.7	3.6	3.5	3.6	3.6	3.7	3.7	3.7	3.8	6
5.6	5.4	5.1	4.8	4.4	4.0	3.9	3.8	3.7	3.8	3.8	3.9	3.9	3.9	4.0	7
6.1	5.9	5.6	5.3	4.9	4.5	4.4	4.3	4.2	4.3	4.3	4.4	4.4	4.4	4.5	8
6.9	6.7	6.4	6.1	5.7	5.3	5.2	5.1	5.0	5.1	5.1	5.2	5.2	5.2	5.3	9
7.6	7.4	7.1	6.8	6.4	6.0	5.9	5.8	5.7	5.8	5.8	5.9	5.9	5.9	6.0	10
7.9	7.7	7.4	7.1	6.7	6.3	6.2	6.1	6.0	6.1	6.1	6.2	6.2	6.2	6.3	11

From *b* to *c*..Diagram I
From *d* to *e*..Diagram II

TABLE IX.—ASTORIA—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER. Days from moon's greatest declination. Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	7.0	7.7	8.4	9.0	9.4	9.8	9.9	9.9	9.8	9.7	9.3	8.9	8.2	7.5	6.6
1	7.1	7.8	8.5	9.1	9.5	9.9	10.0	10.0	9.9	9.8	9.4	9.0	8.3	7.6	6.7
2	6.8	7.5	8.2	8.8	9.2	9.6	9.7	9.7	9.6	9.5	9.1	8.7	8.0	7.3	6.4
3	6.2	6.9	7.6	8.2	8.6	9.0	9.1	9.1	9.0	8.9	8.5	8.1	7.4	6.7	5.8
4	5.5	6.2	6.9	7.5	7.9	8.3	8.4	8.4	8.3	8.2	7.8	7.4	6.7	6.0	5.1
5	4.8	5.5	6.2	6.8	7.2	7.6	7.7	7.7	7.6	7.5	7.1	6.7	6.0	5.3	4.4
6	4.4	5.1	5.8	6.4	6.8	7.2	7.3	7.3	7.2	7.1	6.7	6.3	5.6	4.9	4.0
7	4.6	5.3	6.0	6.6	7.0	7.4	7.5	7.5	7.4	7.3	6.9	6.5	5.8	5.1	4.2
8	5.1	5.8	6.5	7.1	7.5	7.9	8.0	8.0	7.9	7.8	7.4	7.0	6.3	5.6	4.7
9	5.9	6.6	7.3	7.9	8.3	8.7	8.8	8.8	8.7	8.6	8.2	7.8	7.1	6.4	5.5
10	6.6	7.3	8.0	8.6	9.0	9.4	9.5	9.5	9.4	9.3	8.9	8.5	7.8	7.1	6.2
11	6.9	7.6	8.3	8.9	9.3	9.7	9.8	9.8	9.7	9.6	9.2	8.8	8.1	7.4	7.5

From c to *d*..Diagram I
From *a* to *b*..Diagram II

FROM LARGE LOW WATER TO SMALL HIGH WATER. Days from moon's greatest declination. Before—								After—							Hours of moon's transit.
7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
6.4	6.6	6.9	7.2	7.6	8.0	8.1	8.2	8.3	8.2	8.2	8.1	8.1	8.1	8.0	0
6.5	6.7	7.0	7.3	7.7	8.1	8.2	8.3	8.4	8.3	8.3	8.2	8.2	8.2	8.1	1
6.2	6.4	6.7	7.0	7.4	7.8	7.9	8.0	8.1	8.0	8.0	7.9	7.9	7.9	7.8	2
5.6	5.8	6.1	6.4	6.8	7.2	7.3	7.4	7.5	7.4	7.4	7.3	7.3	7.3	7.2	3
4.9	5.1	5.4	5.7	6.1	6.5	6.6	6.7	6.8	6.7	6.7	6.6	6.6	6.6	6.5	4
4.2	4.4	4.7	5.0	5.4	5.8	5.9	6.0	6.1	6.0	6.0	5.9	5.9	5.9	5.8	5
3.8	4.0	4.3	4.6	5.0	5.4	5.5	5.6	5.7	5.6	5.6	5.5	5.5	5.5	5.4	6
4.0	4.2	4.5	4.8	5.2	5.6	5.7	5.8	5.9	5.8	5.8	5.7	5.7	5.7	5.6	7
4.5	4.7	5.0	5.3	5.7	6.1	6.2	6.3	6.4	6.3	6.3	6.2	6.2	6.2	6.1	8
5.3	5.5	5.8	6.1	6.5	6.9	7.0	7.1	7.2	7.1	7.1	7.0	7.0	7.0	6.9	9
6.0	6.2	6.5	6.8	7.2	7.6	7.7	7.8	7.9	7.8	7.8	7.7	7.7	7.7	7.6	10
6.3	6.5	6.8	7.1	7.5	7.9	8.0	8.1	8.2	8.1	8.1	8.0	8.0	8.0	7.9	11

From *d* to *c*..Diagram I
From *b* to *c*..Diagram II

TABLE IX.—PORT TOWNSHEND.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.														
	Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
H.	*Ft.*	*Ft.*	*Ft.*	*Fi.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5
1	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5
2	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4
3	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1
4	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5
5	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1
6	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1
7	3.3	4.4	5.7	6.8	7.4	7.7	7.6	7.6	7.5	7.5	7.3	6.8	6.1	5.4	4.3
8	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5
9	3.7	4.8	6.1	7.2	7.8	8.1	8.0	8.0	7.9	7.9	7.7	7.2	6.5	5.8	4.7
10	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1
11	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4

FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
Days from moon's greatest declination.															
Before—								After—							
7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
Ft	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	0
3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	1
3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	2
3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	3
2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	4
2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	5
2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	6
2.3	2.7	3.4	4.8	6.0	7.2	7.8	8.3	8.4	8.2	8.0	7.5	7.0	6.7	5.9	7
2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	8
2.7	3.1	3.8	5.2	6.4	7.6	8.2	8.7	8.8	8.6	8.4	7.9	7.4	7.1	6.3	9
3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	10
3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	11

TABLE IX.—PORT TOWNSHEND—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.														
	Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5
1	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5
2	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4
3	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1
4	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5
5	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1
6	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1
7	5.3	4.2	2.9	1.8	1.2	0.9	1.0	1.0	1.1	1.1	1.3	1.8	2.5	3.2	4.3
8	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5
9	5.7	4.6	3.3	2.2	1.6	1.3	1.4	1.4	1.5	1.5	1.7	2.2	2.9	3.6	4.7
10	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1
11	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4

FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
Days from moon's greatest declination.															
Before—								After—							
7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	0
7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	1
7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	2
7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	3
6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	4
6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	5
6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	6
6.3	5.9	5.2	3.8	2.6	1.4	0.8	0.3	0.2	0.4	0.6	1.1	1.6	1.9	2.7	7
6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	8
6.7	6.3	5.6	4.2	3.0	1.8	1.2	0.7	0.6	0.8	1.0	1.5	2.0	2.3	3.1	9
7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	10
7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	11

Example VII.—Thus, in Example VI, the high water of February 7 was found to be 3.3 feet above mean low water. The declination being south, diagram I applies, and this high water is the small one. To obtain the fall of the next low water, or small low water, we enter Table IX, for San Francisco, with 0*h.* of moon's transit, and two days after the greatest declination in the first part of the table, and find 1.9 foot, which will be the difference in the height of this high and low water. Entering with the same transit and day in the second part, we find 3.0 feet, which is the rise of the large high above the small low water; the difference between 1.9 and 3.0, or 1.1 foot, is the difference of height of the two successive high waters.

It is easy to see how, in this way, the soundings of a chart can be reduced to what they would be approximately at all the successive high and low waters.

TIDES OF THE GULF OF MEXICO.

On the coast of Florida, from Cape Florida around the peninsula to St. Mark's, the tides are of the ordinary kind, but with a daily inequality which, small at Cape Florida, goes on increasing as we proceed westward to Tortugas. From the Tortugas to St. Mark's the daily inequality is large and sensibly the same, giving the tides a great resemblance to those of the Pacific coast, though the rise and fall is much smaller. Between St. Mark's and St George's island, Apalachicola entrance, the tides change to the single-day class, ebbing and flowing but once in the twenty-four (lunar) hours.

At St. George's island there are two tides a day, for three or four days, about the time of the moon's declination being zero. At other times there is but one tide a day, with a long stand at high water of from six to nine hours. From Cape St. Blas to and including the mouth of the Mississippi, the single-day tides are very regular, and the small and irregular double tides appear only for two or three days, (and frequently even not at all,) about the time of zero declination of the moon. The stand at high and low water is comparatively short, seldom exceeding an hour.

To the west of the mouth of the Mississippi the double tides reappear. At Isle Dernière they are distinct, though a little irregular for three or four days near the time of the moon's zero declination. At all other times the single-day type prevails, the double tides modifying it, however, in the shape of a long stand of from six to ten hours at high water. This stand is shortest at the time of the moon's greatest declination, sometimes being reduced to but one hour. At Calcasieu the tides are distinctly double, but with a large daily inequality. The rise and fall being small, they would often present to the ordinary observer the same appearance as at Isle Dernière. At Galveston the double tides are plainly perceptible, though small, for five or six days at the time of the moon's zero declination. At other times they present the single-day type, with the peculiarity that, after standing at high water for a short time, the water falls a small distance, and stands again at that height for several hours, then continues to fall to low water. Sometimes it falls very slowly for nine or ten hours following high water, and then acquires a more rapid rate to low water. At Aransas Pass and Brazos Santiago the single-day tides prevail. Small, irregular, double tides are only perceived for two or three days at the moon's zero declination. At all other times there is but one high water in the day, with a long stand of from six to nine hours, during which there are often small, irregular fluctuations or a very slow fall. In the following table the mean rise and fall of tides at the above stations are given.

The highest high and the lowest low water occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter. The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus rendered quite irregular.

TABLE X.

Rise and fall at several stations on the Gulf of Mexico.

Stations.	Mean rise and fall of tides.		
	Mean.	At moon's greatest declination.	At moon's least declination.
	Feet.	*Feet.*	*Feet.*
St. George's island, Florida	1.1	1.8	0.6
Pensacola, Florida	1.0	1.5	0.4
Fort Morgan, Mobile bay, Alabama	1.0	1.5	0.4
Cat island, Mississippi	1.3	1.9	0.6
Southwest Pass, Louisiana	1.1	1.4	0.5
Isle Dernière, Louisiana	1.4	2.2	0.7
Entrance to Lake Calcasieu, Louisiana	1.9	2.4	1.7
Galveston, Texas	1.1	1.6	0.8
Aransas Pass, Texas	1.1	1.8	0.6
Brazos Santiago, Texas	0.9	1.2	0.5

TO DETERMINE THE RISE AND FALL OF THE TIDES FOR ANY GIVEN TIME FROM HIGH OR LOW WATER.

It is sometimes desirable to know how far the tide will rise in a given time from low water, or fall in a given time from high water, or to approximate to the time which has elapsed from low or high water, by knowing the rise and fall of the tide in the interval. If the proportion of the rise and fall in a given time were the same in the different ports, this would easily be shown in a single table, giving the proportional rise and fall, which, by referring to Table I, showing the rise and fall of the tide at the port, would give the rise and fall in feet and decimals. The proportion, however, is not the same in different ports, nor in the same ports for tides of different heights. The following Table XI shows the relation between the heights above low water for each half hour for New York and Old Point Comfort, and for spring and neap tides at each place. Units express the total rise of high water above low water, and the figures opposite to each half hour denote the proportional fall of the tide from high water onward to low water. For example, at New York, three hours after high water, a spring tide has fallen six-tenths (sixty-hundredths) of the whole fall. Suppose the whole rise and fall of that day to be 5.4 feet, (Table I,) then three hours after high water the tide will have fallen 3.24 feet, or three feet three inches nearly. Conversely, if we have observed that a spring tide has fallen three feet three inches, we may know that high water has passed about three hours.

TABLE XI.

Giving the height of the tide above low water for every half hour before or after high water, the total range being taken as equal to 1.

Time before or after high water.	New York.		Old Point Comfort.	
	Spring tide.	Neap tide.	Spring tide.	Neap tide.
h. m.				
0 0	1.00	1.00	1.00	1.00
0 30	0.98	0.98	0.98	0.98
1 0	0.94	0.93	0.95	0.94
1 30	0.89	0.86	0.88	0.87
2 0	0.80	0.72	0.80	0.78
2 30	0.72	0.59	0.70	0.68
3 0	0.60	0.45	0.59	0.57
3 30	0.49	0.31	0.49	0.44
4 0	0.39	0.19	0.37	0.34
4 30	0.28	0.10	0.26	0.22
5 0	0.18	0.02	0.17	0.13
5 30	0.09	0.00	0.08	0.05
6 0	0.05	....	0.03	0.01
6 30	0.00	....	0.00	0.00

TIDES IN COASTING.

By observing the time of high water and low water along the coast we find the places at which they are the same. The map of co-tidal lines (Sketch No. 65, C. S. Rep., 1857) shows that it is high water nearly at the same hour all along the coast from Sandy Hook to Cape Cañaveral; of course not in bays and harbors and up the rivers, but on the outer coast.

It is high water exactly at the same hour all along the line marked XII, seen on the chart, near Sandy Hook, and north and south of Hatteras, and with small interruptions at Cape Lookout and Cape Fear, all the way to near Cape Cañaveral. The same line extends eastward to near Block island, and south of Nantucket, and then passes away from our coast. At full and change of the moon, along this line, (approximately,) it is high water at twelve o'clock, Greenwich time, the local time of high water depending upon the longitude of the place; or, to speak more correctly, in the average of a lunar month it is high water so many hours after the time of the moon's passing the meridian of Greenwich. By these lines, called co-tidal lines, we can determine what tidal currents the navigators must expect to meet in coasting; and for this purpose we divide the ports of the coast into two sets, those south and those north of New York.

The sailing lines of coasters, bound to southern ports this side of the straits of Florida, are marked upon the map, and also those bound through the sounds to eastern ports, and outside to Halifax and European ports.

VESSELS TO AND FROM PORTS SOUTH OF NEW YORK.

South of Sandy Hook, New Jersey, the line of XII hours is nowhere more than 18 miles from the coast; that of XI$\frac{3}{4}$ nowhere more than 35 miles; that of XI$\frac{1}{2}$ nowhere more than 48; and XI nowhere more than 110. The distance of these lines of XII to XI hours, (corresponding within four minutes to VII and VI of New York time,) for different parts of the coast, is shown from Table A, where the first column gives the name of the place, and the second, third, fourth, fifth, respectively, the distances of the co-tidal lines of XII, XI$\frac{3}{4}$, XI$\frac{1}{2}$, and XI hours. The distances are measured from the ports on perpendiculars to the co-tidal lines. They may be taken as if measured on the parallel of latitude at all the points for the line of XII hours, and at all between Sandy Hook and Cape Hatteras for the lines of XI$\frac{3}{4}$ and XI$\frac{1}{2}$ hours.

A.

Names of locations.	Distance from coast, measured on perpendicular to co-tidal lines.			
	At XII hours.	At XI$\frac{3}{4}$ hours.	At XI$\frac{1}{2}$ hours.	At XI hours.
	Nautical miles.	*Nautical miles.*	*Nautical miles.*	*Nautical miles.*
Sandy Hook	12	32	53	100
Barnegat	2	29	39	78
Cape May	15	30	46	92
Cape Henlopen	18	33	47	92
Assateague	7	22	36	82
Cape Henry	12	28	43	100
Cape Hatteras	....	8	20	63
Ocracoke inlet	....	11	26	71
Cape Lookout	....	7	18	56
Beaufort entrance, North Carolina	6	15	24	63
Cape Fear	....	6	16	55
Cape Roman	....	10	21	67
Charleston light	3	15	27	70
Port Royal entrance	5	17	29	78
Tybee entrance	6	17	31	82
St. Mary's entrance	12	25	40	110
St. John's entrance	17	35	48	....
Cape Cañaveral	16	....	....	....
Cape Florida	....	....	....	....

The co-tidal lines are in such directions that at 10, 20, and 30 miles from the coast, between Sandy Hook and the St. John's there is but a variation of seven minutes, and even to Cape Cañaveral only of eight minutes.

Keeping ten miles from the shore the coaster would pass from 12 hours at Sandy Hook to 11 hours 45 minutes at Hatteras, and increase again irregularly to 12 hours 7 minutes at the St. John's, as shown more explicitly in Table B. These three tracks of 10, 20, and 30 miles are inside of the cold wall of the Gulf Stream, and generally in the cold current, except at Cape Cañaveral.

B.

Names of stations.	Co-tidal hour at 10, 20, and 30 nautical miles from the coast, perpendicular to the coast.		
	Ten miles off.	Twenty miles off.	Thirty miles off.
	h. m.	*h. m.*	*h. m.*
Sandy Hook	12 0	11 52	11 45
Barnegat	11 52	11 44	11 35
Cape May	12 5	11 53	11 45
Cape Henlopen	12 7	11 57	11 48
Assateague	12 0	11 48	11 37
Cape Henry	12 5	11 48	11 42
Cape Hatteras	11 45	11 30	11 22
Ocracoke inlet	11 47	11 36	11 25
Cape Lookout	11 45	11 30	11 20
Beaufort entrance, North Carolina	11 55	11 38	11 25
Cape Fear	11 38	11 25	11 18
Cape Roman	11 45	11 33	11 24
Charleston light	11 52	11 38	11 25
Port Royal entrance	11 57	11 45	11 32
Tybee entrance	11 55	11 43	11 30
St. Mary's entrance	12 8	11 57	11 47
St. John's entrance	12 7	11 57	11 50
Cape Cañaveral	12 8	....	....
Cape Florida	13 10	....	....

It follows, then, as a general thing, from these two tables, that the coaster, in passing from Sandy Hook to the St. John's, would have the tides the same, within some fifteen minutes, as if he remained at Sandy Hook; so that leaving, for example, at high water, he would, according to the elapsed time, have the ebb and flood alternating every six hours and a quarter, nearly, as if he had remained near Sandy Hook. As the flood tide sets in generally to the northward and on shore, and the ebb to the southward and off shore, he would know by the time that elapsed from his departure and the period of the tide at which he started what tidal current she might expect to meet as he passed along the coast. This of course, is not peculiar to Sandy Hook as a point of departure, but would be true for any of the entrances given in the table, taking care not to mistake the time of tides within for that at the entrance.

By referring to George W. Blunt, esq., I have obtained the tracks of sailing and steam vessels passing from New York to ports to the south of it, as shown by the lines on the chart accompanying this paper. (See Sketch No. 65, C. S. Rep., 1857.) Tracing these on the map of co-tidal lines, I have determined how the navigator would find the tides as he passes from port to port. The results are shown in the annexed table, (C,) in which the port between which and Sandy Hook the mariner passes is at the head of the table, and, at the side, the place off which the co-tidal hours will be found, as stated in the table.

C.

Off—	Co-tidal hours on sailing lines measured on parallels of latitude of places named in the first column, between New York and—							
	Delaware bay.	Chesapeake bay.	Ocracoke inlet.	Cape Fear.	Charleston.	Savannah.	St. John's.	Cape Florida.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Sandy Hook	12 5	12 5	12 5	12 5	12 5	12 5	12 5	12 5
Barnegat	11 57	11 57	11 57	11 57	11 57	11 57	11 57	11 57
Cape May	12 10	11 52	11 45	11 45	11 45	11 45	11 45	11 45
Cape Henlopen	....	11 51	11 43	11 43	11 43	11 43	11 43	11 43
Assateague	....	11 55	11 33	11 33	11 33	11 33	11 33	11 33
Cape Henry	....	12 13	11 24	11 24	11 24	11 24	11 24	11 24
Cape Hatteras	....	....	11 48	11 48	11 48	11 48	11 48	11 48
Ocracoke inlet	....	....	....	11 42	11 42	11 42	11 42	11 42
Cape Lookout	....	....	....	11 39	11 39	11 39	11 32	11 24
Beaufort entrance	....	....	....	11 39	11 39	11 39	11 32	11 24
Cape Fear	....	....	....	....	11 36	11 36	11 24	11 0
Cape Roman	....	....	....	....	11 46	11 46	11 19	....
Charleston light	....	....	....	....	....	11 52	11 18	....
Fort Royal entrance	....	....	....	....	....	12 3	11 18	....
Tybee entrance	....	....	....	....	....	....	11 16	....
St. Mary's entrance	....	....	....	....	....	....	11 55	....
St. John's entrance	....	....	....	....	....	....	12 10	....
Cape Cañaveral	....	....	....	....	....	....	....	....
Cape Florida	....	....	....	....	....	....	....	....

Thus from Sandy Hook to Delaware bay, starting with 12 hours 5 minutes, off Barnegat there would be, at the same instant, 11 hours 57 minutes, and off Cape May 12 hours 10 minutes, so that the navigator would have the same succession of tides whether he remained at Sandy Hook or passed onward to Delaware bay, or whether he came from Delaware bay to Sandy Hook. So from Sandy Hook to Charleston he will find, at the same instant, 12 hours 5 minutes at Sandy Hook, 11 hours 57 minutes off Barnegat, 11 hours 45 minutes off Cape May, and so onward upon the parallels of latitude for the several points. *For all practical purposes, then, of coasting, the succession of the tides, and, of course, of the tidal currents of flow and ebb, will be the same as if the navigator remained stationary.* Leaving at low water he will meet the flood for 6 hours 15 minutes, and then the ebb for another 6 hours 15 minutes, and so on. It is the simplest of all rules that has thus come out of this investigation. That remarkable change of the temperature between the waters of the in-shore cold current and the warm waters of the Gulf Stream, occurring in so short a distance that Lieutenant Bache called it the "cold wall," takes place at distances off the coast of from 170 to 29 miles, (see Table D,) between Sandy Hook and Cape Cañaveral, measured, from the several points named in the table, at right angles to the direction of the course, or measured along the parallels of latitude of the points, at distances from 195 to 28 miles, between Assateague and Cape Cañaveral, (Table D.) The points where the parallels north of Assateague meet this division line have not been accurately determined.

The annexed table shows these distances measured at right angles and on the parallels.

D.

Distance from coast to "cold wall" of Gulf Stream, off—	Measured at right angles to coast.	Measured on parallel of latitude.
	Nautical miles.	*Nautical miles.*
Sandy Hook	170	
Barnegat	135	
Cape May	137	
Cape Henlopen	137	
Assateague	95	195
Cape Henry	92	107
Cape Hatteras	30	31
Ocracoke inlet	53	52
Cape Lookout	53	65
Beaufort entrance	62	
Cape Fear	54	97
Cape Roman	57	103
Charleston light	61	95
Port Royal entrance	79	97
Tybee entrance	79	95
St. Mary's	90	87
St. John's	85	82
Cape Cañaveral	29	28
Cape Florida		

The coasting line of thirty miles keeps inside of the cold wall all the way to Cañaveral, and all the routes traced on the chart from Sandy Hook to southern ports are on the inside of it. The Gulf Stream lines, as drawn on the chart, show how the route to Bermuda and to the Bahamas cuts the alternate bands of warm and cold water of the Gulf Stream.

Vessels to and from ports east of New York.

The plate shows the sailing lines of vessels bound from New York to eastern ports and to Halifax, outside. The annexed table (E) gives the Greenwich time of high water off the several points named in the first column on the routes to and from the places named in the heading of the table. The distances are measured at right angles to the co-tidal curves.

E.

Off—	Co-tidal hours on sailing lines between New York and—						
	Newport.	New Bedford.	Nantucket.	Boston.	Portsmouth.	Portland.	Halifax.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Sandy Hook							12 5
Throg's Point	16 16	16 16	16 16	16 16	16 16	16 16	
Fisher's island	13 48	13 48	13 48	13 48	13 48	13 48	
Block island	12 16	12 16	12 16	12 16	12 16	12 16	11 30
Monomoy				16 10	16 10	16 10	
Cape Cod				14 35	14 35	14 35	12 15
Cape Ann					15 00	14 40	
Portland						15 30	

In passing from New York to an eastern port the first great change in the tides and tidal currents is between the East river and Long Island sound; the difference between Governor's island and Negro Point, on Ward's island, at the eastern entrance to Hell Gate, is two hours and forty-five minutes. Between this point and Throg's Point the change is small. The mariner is now in the full tide of the sound, and between Throg's Point and Fisher's island there is a difference of time of but two hours and twenty minutes, the greatest part of which is at the head of the sound and at its entrance—that is, near Throg's Point and Fisher's island. From off New London to off Sand's Point the difference is but one hour and forty minutes; so that if the mariner, instead of remaining at Throg's Point, passes onward to Fisher's island, he would lose but half a tide in the whole passage. In other words, he would have the same succession of rise and fall, according to the time elapsed, whether stationary or passing onward, within two hours and a half, or less than half a tide.

The tidal current lines show that even a less allowance is to be made for the change of current than for the change of tide, the difference in the change of current between Throg's Point and Fisher's island, along the middle of the sound, being of no practical importance. Passing out of Long Island sound the tidal hours grow earlier, until off Block island that of Sandy Hook is again reached. The co-tidal line of Sandy Hook and Block island being the same, it is the struggle of the same tide through New York bay and the narrow East river, and obstructed Hell Gate, and through Fisher's island and Long Island sound, and to Throg's Point. The tidal currents meet near Throg's Point.

The lower part of Narraganset bay has the co tidal hour twelve hours, nearly. Buzzard's bay has nearly the same co-tidal hour, the tide wave reaching the shore at nearly the same time all around the bay.

It would be impossible to give in a small compass a minute account of the tides of Martha's Vineyard and Nantucket sound. In general, it may be said that as far as Holmes's Hole and Wood's Hole they resemble those of Block Island sound, and afterwards those of Monomoy, at the eastern entrance; but this generalization is unsatisfactory without more details than there is space here to give. In these sounds takes place the remarkable change of between three and four hours, the greatest change of our coast, dislocating, as it were, the times of high water at places south and west and east and north of Nantucket. The whole of this change takes place between the eastern entrance of Nantucket sound and the western of Martha's Vineyard, giving rise to quite a complex condition of both tides and currents, which it has occupied much time to unravel. The dominant co-tidal line of our coast, from Block island to Cape Cañaveral, is that of 12 hours of Greenwich time; that of our eastern coast, from Nantucket to Passamaquoddy, is, in general, 15 hours. Passing out of Nantucket sound, coasters carry nearly the same co-tidal hour to Cape Cod, and thence vary their time about half an hour in passing to Boston, to Portsmouth, to Portland, or to Passamaquoddy. It has long been known that the tidal almanac for Boston might practically be used for eastern ports. Vessels from New York to Halifax, and New York to Europe, which keep outside, and should keep well off the Nantucket shoals, and off George's, as shown by the track on the chart, vary their co-tidal hour but little, keeping between the lines of 12 and 11½ until quite well on their course, and beyond Cape Sable. The same rule will apply to their case as has been given for vessels between New York and a southern port.

APPENDIX No. 9.

REPORT TO THE SUPERINTENDENT BY ASSISTANT L. F. POURTALES, IN CHARGE OF THE FIELD AND OFFICE WORK, RELATING TO TIDAL OBSERVATIONS.

COAST SURVEY OFFICE, *October* 1, 1864.

SIR: I have the honor to submit the following report on the field and office work performed by the tidal party under my charge during the past year.

Field-work.—The following permanent tidal stations have been continued uninterrupted during the year ending at this date: Boston, Mass., New York, Old Point Comfort, Va., San Diego, and San Francisco, Cal., and Astoria, Oregon. The station at Eastport remained in charge of Assistant E. Goodfellow until April 1, his place being then taken by Sub-Assistant A. T. Mosman. On July 18 the station was discontinued, and the instruments were transferred to Portland, Me., where they were set up by Mr. H. W. Richardson, and started on the first of August.

Mr. M. C. King, the observer at Old Point Comfort, resigned the position, which he had filled satisfactorily since the establishment of the station, on the 1st of March. Since that date the station has been in charge of Ordnance Sergeant C. Kelly, U. S. A.

A self-registering tide-gauge was set up at Bay Point, Port Royal sound, S. C., by Assistant C. O. Boutelle; observations began August 22, but were unsatisfactory, the locality being too much exposed. The gauge will be transferred to a more sheltered place in the same sound.

The three stations on the western coast have, as in preceding years, been under the efficient supervision of Captain G. H. Elliot, of the corps of engineers, U. S. A.

The observations at most of the stations have been of a satisfactory character.

The following table gives a recapitulation of the tidal observations received during the past year, exclusive of those taken by the hydrographical parties for the reduction of their soundings.

Section.	Station.	Observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation.		Total days.	Remarks.
					From—	To—		
I	Eastport, Me.	E. Goodfellow, A. T. Mosman.	S. R.	Permanent.	Oct. 1	July 18	292	
I	Portland, Me.	H. W. Richardson	do.	do.	Aug. 1	Sept. 30	61	
I	Boston Dry Dock	T. E. Ready	Box	do.	Oct. 1	do.	366	
II	Governor's island, N. Y.	R. T. Bassett	S. R.	do.	do.	do.	366	
II	Brooklyn, N. Y.	do.	Box	do.	do.	do.	366	Day tides for comparison with Governor's island.
III	Old Point Comfort, Va.	M. C. King, C. Kelly	S. R.	do.	do.	do.	366	
V	Port Royal, S. C.	C. O. Boutelle	do.	do.	Aug. 22	Sept. 18	28	
X	San Diego, Cal.	A. Cassidy	do.	do.	Oct. 1	Sept. 30	366	
X	San Francisco, Cal.	H. E. Uhrlandt	do.	do.	do.	do.	366	
XI	Astoria, Oregon	L. Wilson	do.	do.	do.	do.	366	

Office-work.—The following persons have been attached to this division of the office during the past year, though never all at the same time: R. S. Avery, J. Downes, P. H. Donegan, M. Thomas, and F. R. Pendleton.

Mr. R. S. Avery remained connected with this division until the end of October, 1863, being engaged in revision of tidal reductions. He was then transferred to the computing division.

Mr. P. H. Donegan read off the times and heights of tides from the sheets of the self-registering tide-gauges, and made the reductions of the same. He was transferred to the charge of the archives on the first of April.

Mr. J. Downes took Mr. Donegan's place on the first of April, and continues on the same work at this time.

M. Thomas continues to copy the readings of the self-registering tide-gauges for preservation in the archives; also does miscellaneous clerical work.

F. R. Pendleton has continued to make the reductions of the observations from the western coast.

Very respectfully, your obedient servant,

L. F. POURTALES,

Assistant United States Coast Survey, in charge of tidal division.

Prof. A. D. BACHE, LL.D., *Superintendent United States Coast Survey.*

ON OBSERVATIONS OF TIDES AT TAHITI, MADE UNDER THE DIRECTION OF CAPTAIN JOHN RODGERS, U. S. N., (SKETCH No. 40.)

The tides at Tahiti have long been known to exhibit the peculiarity of occurring nearly at the same hour of every day, indicating an almost total elimination of the lunar tide.

As far as we know, the tides of no other part of the globe present this extraordinary feature. No explanation fully satisfactory has yet been proposed for this phenomenon.

From their bearing on the laws regulating the tides on the North American coast of the Pacific ocean, accurate tidal observations in central parts of that ocean were a great desideratum, and advantage was, therefore, taken of the surveying expedition, under the command of Captain John Rodgers, U. S. N., by furnishing him with one of Saxton's self-registering tide-gauges, with the request to set it up at some suitable point.

The town of Papeete, on the island of Tahiti, was selected by Captain Rodgers, and the tide-gauge left there in 1856 under the charge of an intelligent French soldier. The observations began on the 27th of April, but up to June 2 were so frequently interrupted as to be of little use. After that date they are nearly complete to October 12, subsequent to which time no observations have been received.

On the accompanying diagram (see Sketch No. 40) the mean local time of each high water has been plotted in such a manner that the abscissae represent the days of the month; the ordinates the hours of the day. An inspection of the diagram will show that during part of the month of June the tide appears to have followed the general rule, occurring later every day, so that there was a high-water successively at all the hours of the twenty-four. In July, however, the case was quite different. The high-waters occurred at a later hour on successive days, but only until they had reached three or four hours, and in one case five, afternoon or midnight, when they came back abruptly to the neighborhood of twelve, to follow again a similar cycle. This type they preserve to October 12, when the observations ceased, only the range and the abruptness of the return to an earlier hour becoming lessened. It will also be remarked that the midnight tides diverge less from that hour than the midday tides from noon. The times of low water have, as may be expected, similar relations to 6 a. m. and 6 p. m.

Taking the mean of all the observations we find 59 minutes past noon and 53 minutes past midnight for the average time of high water, and 45 minutes past six for the average time of low water, both morning and night.

Diagram 2 (Sketch No. 40) shows the variations from that mean, arranged according to the moon's transit. The curve exhibited might be called the half-monthly inequality in the soli-tidal interval, in analogy to the curve of half-monthly inequality, of the luni-tidal interval of ordinary tides.

With regard to the heights the statements received are not quite precise as to the scale used in the self-registering tide-gauge, and some uncertainty arises from the zero-point having been repeatedly altered, owing to the necessity of using the same paper on the gauge several times. On the best supposition that can be made we find the mean rise and fall to be 0.87 ft. The observations made at the same port for a few days by Captain Sir Edward Belcher, R. N., in 1840, (Phil. Trans., 1843,) gave a mean rise and fall of only 0.56 ft. The diurnal inequality is well marked, and the half-monthly inequality regular and normal.

If we examine the variations of the intervals near the time of the summer solstice, we shall find that, on the 3d of June or a little after, the moon's upper transit comes at noon; the intervals for midday tides is at its mean value. Then the interval increases rapidly every day as the moon's transits come later, until they come near the middle of the afternoon, when there is a sudden change of 6*h.* or 8*h.* in the course of two or three days, during which time the tides are so small that their times and intervals cannot be well determined. The high-waters then seem to pass under the influence of the moon's inferior transits, and the intervals are reduced to their minimum values, or become negative. The intervals then increase rapidly again for a considerable part of half a lunation until they pass again under the action of, and finally under the control of, the moon's superior transits. The same law will be observed to prevail throughout the period of observation, but the inequality rapidly decreases in amount as we depart from the solstice. Similar observations apply *mutatis mutandis* to the midnight tides.

The range of the tides seems to be considerably less near the solstice than they are near the equinox.

There seem to have been some notable changes in the mean level of the ocean in the month of July.

Hopes were entertained of obtaining more observations, and a supply of paper was forwarded to the United States consul some years ago, but no answer has ever been received. It has been thought advisable, therefore, to publish the results as far as they have been obtained.

APPENDIX No. 10.

REPORT OF ASSISTANT J. E. HILGARD, IN CHARGE OF THE OFFICE.

COAST SURVEY OFFICE, *Washington, November* 1, 1864.

SIR: I have the honor to submit herewith the annual report of the operations of the Coast Survey office' which has remained under my charge during the past year.

In the general direction of the office I was assisted until June by Prof. F. A. P. Barnard, who then withdrew to fill the chair of president of Columbia College. The loss of his valuable assistance has been severely felt, but the impress of his mind and the marks of his shaping hand upon every subject that passed under his care will long remain.

The clerical duties of the office have been efficiently performed, as during the preceding year, by Mr. V. E. King, aided by Mr. Wm. Gadsby, jr. Upon the retirement of Prof. Barnard, that portion of his duties relating to the issue of maps and charts was assumed by Mr. King.

To Samuel Hein, esq., the disbursing officer of Coast Survey, and to Joseph Saxton, esq., the assistant in charge of the office of weights and measures, I beg leave to express my indebtedness for aid derived from their advice and experience.

The detailed accounts of the work performed in the several divisions of the office are herewith presented.

J. E. HILGARD,
Assistant Coast Survey, in charge of office.

HYDROGRAPHIC DIVISION.—The operations in this division have been continued under the direction of *Captain C. P. Patterson.* These, as heretofore, have included the arrangement of hydrographic matter for the hands of the engraver, the verification of charts, and the preparation of supplementary data for revised editions of sheets already published. The outfit and repairs of vessels used by the field parties have, as usual, been supervised by Captain Patterson. For office details two draughtsmen were on duty during the greater part of the year. Their occupation has been as follows:

Mr. Arthur Balbach made, under the direction of Captain Patterson, the comparisons and verification necessary in advance of the issue of charts from the office; the arrangement of notes for the charts; most of the plotting required in the preparation of new charts, as also that needed for new editions of sheets heretofore published. During part of the year Mr. Balbach was employed in the special survey of Boston harbor.

Mr. Louis Karcher continued the usual routine of service in the division until the end of September. He made the projections for the hydrographic sheets of the year; plotted original hydrographic work, and made reductions and verifications. His acceptable services terminated on the 1st of October, when he resigned.

TIDAL DIVISION.—The following report of the occupation in this division during the past year is submitted by *Assistant L. F. Pourtales.*

Mr. R. S. Avery remained connected with this division engaged in revision of tidal reductions until the end of October, 1863, when he was transferred to the computing division.

Mr. P. H. Donegan made the readings from the sheets of the self-registering tide-gauges and reduced the results. He was detached from this division and put in charge of the archives on the 1st of April.

Mr. J. Downes was assigned to this division, in Mr. Donegan's place, on the 1st of April, and has continued the work up to this time.

M. Thomas has continued to do the copying required, particularly of the readings of the self-registering tide-gauges, in shape for preservation in the archives.

F. R. Pendleton has continued to make the reductions of the observations from the western coast.

COMPUTING DIVISION.—The duties of the division in charge of Assistant *C. A. Schott* have been increased by the assignment of certain astronomical longitude computations, but no addition has been made to the effective force employed in it.

Mr. R. S. Avery, formerly of the tidal division of the office, joined the computers on the 28th of October, 1863. Mr. James Main resigned on the 1st of August, 1864, on account of ill health. He had been connected with the survey (excepting for a short period in 1859) since November, 1851; by his resignation the office loses an experienced and industrious computer.

In consequence of the assignment to this division of the reduction of the observations of Pleiades occultations between 1856 and 1861 for the determination of American longitudes and correction of the lunar ephemeris, according to the plan of Prof. Benjamin Peirce, and under his general direction, the distribution of the work assigned to the several computers has been slightly modified. Mr. Main was engaged on the first computation of the occultations, and Mr. Avery on the second or check computation. Mr. Main's place was afterwards filled by Mr. Werner, to whom the same duty was assigned.

On the night of November 13–14, 1863, Mr. Schott observed and recorded the phenomena of shooting stars, assisted by several observers. He was engaged between November 16 and November 22, 1863, in investigating the deflection of the compasses of the turreted iron-clad steamer Roanoke, then lying off Newport News, in James river. In July and August he determined and located ranges of projectiles fired from 15-inch guns, mounted on the shore of the Potomac, below Alexandria, and in September and October assisted in determining ranges of similar guns in New York and Boston harbors. His reports on various subjects this year include: The fourth report on deflections of compasses in iron-clad vessels, (see report of the compass committee, report of the National Academy;) a table of observations of shooting stars; results of a discussion of the compensation of base bars; a paper on the geodetic *n* point problem; a paper on great circle sailing on he polyconic projection; a report on the least square reduction of the primary triangulation in Section I, and application to that portion connecting it with the Epping base; formulæ and application for ricochet shots. Over 1,000 separate observations of occultations of the Pleiades have been collected, about 700 of which will be submitted to reduction. Mr. Schott also attended to the comparison of the two computations before mentioned, and furnished information as needed by either field or office parties.

The following detailed statement shows the work performed by each computer:

Assistant Theodore W. Werner completed the reduction of the following triangulations: Penobscot bay, Section 1, 1862, G. A. Fairfield, observer; Neuse river, N. C., 1863, same observer; coast of New Jersey, south of Navesink, N. J., 1861–'62–'63, J. Farley, observer; vicinity of Baltimore, 1863, C. H. Boyd, observer; small additional triangulation, by G. Davidson, of the Canal de Haro, 1854; St. George's river, 1863, Chas. Ferguson, observer; Charlotte harbor, Fla., 1860–'61, W. R. Terril, observer; Penobscot bay, Me., 1863–'64, S. C. McCorkle, observer; he also made some miscellaneous computations, and a second computation of the horizontal angles at stations Mt. Pleasant, Thompson, and partly of Beaconpole; furnished an abstract of angles of the triangulation near Machias bay, Me., and commenced the reduction of the observations of the Pleiades occultations between 1856 and 1861. Mr. Werner was prostrated by sickness in April and part of May.

Mr. Eugene Nulty completed the reduction of the Penobscot bay triangulation, 1862, S. C. McCorkle, observer; and nearly completed the calculations for time, latitude, and telegraphic longitudes, also of azimuth and magnetic variation, at eleven stations in Western Virginia, Ohio, and Maryland, 1864, G. W. Dean and party, observers. He then took up geodetic computations, and also performed some work on daily magnetic records.

Mr. James Main completed the reduction of Assistant Schott's magnetic observations, in Section I, 1863, attended to some miscellaneous astronomical computations, and was engaged since October 28, 1863, on the first reduction of observations of Pleiades occultations. He resigned August 1, 1864.

Dr. Gottlieb Rumpf prepared the annual statistics of the geodetic operations; attended to the geographical registers; prepared the geographical positions determined for publication; revised horizontal angles, station Beaconpole; revised the computation of the triangulation near Baltimore, 1863, and of Penobscot bay, 1862; computed the triangulation between Machias and Passamaquoddy bays, 1863; attended to miscellaneous geodetic work; assisted in the least-square reduction of the primary triangulation near the Epping base, and to the south and westward; and computed probable errors of the directions of this triangulation.

Mr. R. S. Avery was transferred to this division, October 28, 1863, for the purpose of making the check computation for longitudes from observations of the Pleiades, upon which work he has been engaged since, making very satisfactory progress.

Mr. E. H. Courtenay attended to the clerical duty of the division—to copying for permanent record and for field parties; converted measures, and performed some other computations connected with horizontal angles. He also completed the duplicate records of the survey (geodetic and astronomical) prior to 1844.

R. Freeman was during part of the year supplied with miscellaneous copying.

The duplicate records of geodetic, astronomical, and magnetic observations, still in my special charge, number 1,542 volumes.

DRAWING DIVISION.—Under the immediate direction of Assistant Hilgard the work has been distributed in this division by Mr. W. T. Bright. The occupation of the several draughtsmen has been as follows:

Assistant M. I. McClery has continued filling in details upon the photographed outline of coast maps No. 10, Cape Ann to Plymouth harbor, Mass., and No. 53, Rattlesnake shoals to St. Helena sound, S. C., scale $\frac{1}{80000}$; the hill topography of coast map No. 10, Cape Ann to Plymouth harbor, Mass., and that of No. 11, Plymouth harbor to Hyannis harbor, Mass., on a scale of $\frac{1}{40000}$, to be reduced by photography to the scale of $\frac{1}{80000}$. He has traced for photographing the special survey of part of the Ohio river, from Cairo to Mound City, and drawn portions of topography for a finished map of Potomac river, sheet No. 1, scale $\frac{1}{60000}$.

Mr. E. Hergesheimer, as usual, has had charge of the preparation of tracings from plane-table sheets for photographic reduction to the publication scale of coast maps No. 8, Seguin island to Kennebunk Port, Me.; No. 10, Cape Ann to Plymouth harbor, Mass.; No. 11, Plymouth harbor to Hyannis harbor, Mass.; No. 53, Rattlesnake shoals to St. Helena sound, S. C.; No. 54, St. Helena sound, S. C., to Ossabaw sound, Ga.; also upon the finished map of Hudson river, sheet No. 1, New York to Haverstraw, scale $\frac{1}{60000}$, and Boston harbor, (new edition,) scale $\frac{1}{40000}$. He revised the hydrography of the preliminary chart of Potomac river, sheet No. 2, Piney Point to Lower Cedar Point, scale $\frac{1}{60000}$; compiled a road map of Washington and vicinity for the use of the army; made a manuscript map for military purposes of Wilmington and vicinity, N. C., and has drawn the hill topography of the map of Appomattox and James rivers, Va., for photographing. He also added supplementary details to the chart of Washington sound, (new edition;) finished hill topography for the map of Grand Gulf, Miss.; made the additions of the year to the Congress map; arranged the lettering for all the finished maps and charts in process of publication, and has made verifications, projections for field parties, and diagrams. Between June 18 and July 30 Mr. Hergesheimer was engaged for the Quartermaster General U. S. A., in a topographical survey of the Soldiers' National Cemetery, at Arlington, Va.

Mr. A. Lindenkohl was engaged with the late Lieutenant J. R. Meigs, corps of engineers, in West Virginia, from October 3, 1863, until February 15, 1864, since which time he has compiled additional material for the military maps of the mountain region of Tennessee and North Carolina, southeastern Virginia, eastern Virginia, and the northern part of Florida, and for extending the limits of maps used in the armies so as to include nearly the entire area of the States in rebellion upon a uniform scale of ten miles to the inch. He has completed the preliminary chart of the Atlantic coast No. 1, Cape Sable to Barnegat inlet, scale $\frac{1}{1200000}$, and made additions to that of the Gulf coast, from Mobile Point to Corpus Christi bay, Texas, scale $\frac{1}{1200000}$; continued the drawing of preliminary chart of part of the western coast of the United States, from Point Pinos to Bodega Head, including the bay of San Francisco, scale $\frac{1}{200000}$; completed preliminary chart of Half Moon bay, Cal., scale $\frac{1}{20000}$; Cape Lookout shoals, N. C., scale $\frac{1}{80000}$; Light-house inlet and the inland passage to Folly river, S. C., scale $\frac{1}{20000}$; made additions to the preliminary chart of Nantucket shoals, scale $\frac{1}{200000}$, and has drawn, as far as the material goes, a chart of Eastport harbor, Me., scale $\frac{1}{30000}$. He has reduced additional hydrography for coast chart No. 7, Muscongus bay to Portland, Me.; No. 8, Seguin island to Kennebunk Port, Me.; and Nos. 40 and 41, Albemarle sound, N. C., scale $\frac{1}{80000}$, and has made projections on copper, projections for field parties, progress sketches, additions from time to time to the published war maps, and special lithographic maps for the Navy Department.

Mr. L. D. Williams, until November 30, when he resigned, was engaged upon projects, copper-plate projections, lettering, additions to the Congress map, and verifications.

Mr. H. Lindenkohl has selected and traced for reduction by photography the remaining hydrography for the chart of Kennebec and Sheepscot rivers, Me., scale $\frac{1}{40000}$; continued the hydrographic reduction of Port Royal sound, including Beaufort, Broad, and Chechessee rivers, S. C., scale $\frac{1}{60000}$, and reduced additional topography for sheet No. 4, of Potomac river, (Indian Head to Little Falls bridge,) scale $\frac{1}{40000}$. Besides drawing the hill topography, on the scale of the original survey, for a map of Vicksburg and approaches, he made additions to the chart of Albemarle sound, N. C., scale $\frac{1}{200000}$, and engraved on stone from his own drawing a map of the city of Richmond, Va., and portions of other maps of the States in rebellion. He has also been engaged upon projections, progress sketches, and tracings of various kinds.

Mr. Lindenkohl, after a career of great usefulness in the office, sailed for Europe in August.

Mr. F. Fairfax has drawn the hill topography for a map of Bodega bay, Cal., scale $\frac{1}{30000}$; made additions to that of Newport harbor, R. I., scale $\frac{1}{20000}$, and traced for photographing the topography of St. Helena sound, S. C., scale $\frac{1}{40000}$, and that of Tomales bay, Cal., scale $\frac{1}{30000}$. He has prepared for engraving the details upon a photographed outline of Rockland harbor, Me., scale $\frac{1}{20000}$; the topography for a chart of the main entrance to Charlotte harbor, Fla., scale $\frac{1}{40000}$, and additional topography for coast maps Nos. 40 and 41, Albemarle sound, N. C., scale $\frac{1}{80000}$, and for a preliminary chart of the sound on a scale of $\frac{1}{200000}$. He has also made projections for field parties, diagrams, and tracings, and is now engaged in reducing additional work for the chart of Delaware and Chesapeake bays, scale $\frac{1}{400000}$.

Mr. F. Engel during the time he was attached to the division was engaged upon diagrams, miscellaneous drawings, and reduction of material for a chart of the Atlantic coast, No. 1, (Cape Sable to Barnegat inlet,) scale $\frac{1}{1200000}$.

Mr. W. B. McMurtrie continued on duty in Philadelphia, connected with the special survey, until January 26, since which time he has been employed in plotting hydrographic work, in tracing for photographic reduction, and in drawing the preliminary chart of Hudson river, from Glasco to Troy, scale $\frac{1}{40000}$, and that of the mouths of Roanoke river, N. C., scale $\frac{1}{30000}$. He has also been engaged upon projects for maps, in inking, plane-table sheets, and in tracing.

Mr. J. W. Maerdel was employed on photographic tracings and other miscellaneous work until December, 1863, when he was assigned to the party of Assistant C. O. Boutelle as hydrographic draughtsman.

Mr. E. Willenbucher, until August, when he was assigned to the party of Assistant Boutelle as hydrographic draughtsman, was engaged in plotting hydrographic work, in tracing, and in coloring proofs.

Mr. E. Molitor was assigned to duty in this division in December, 1863, and, until April 21, was engaged on tracings, diagrams, verifications, and additions to the war maps, when he left the office to join the army. He rejoined the office in September, and, until the end of that month, aided in preparing for issue a new map of Mobile bay, when he again left.

Messrs. B. Hooe, J. H. Logan, and *W. Fairfax* have been engaged upon tracings, statistics, tracing for photographic reduction, inking plane-table sheets, and other miscellaneous work.

Mr. D. Koch was employed in the office from April until October upon tracings and coloring lights on charts.

ENGRAVING DIVISION.—The division has remained under the charge of Mr. Edward Wharton since the date of the last report. The duties of clerk to the division were performed, after Mr. G. J. Pinckard's resignation, which occurred in December, by Mr. Henry C. Saxton, until the 19th of May. Since the first of July the position has been filled by Mr. George C. Schaeffer, jr.

The engraving force at present consists of eighteen engravers of various degrees of skill. A detailed statement of the occupation of each, which differs but little from year to year, will be found below.

The engraving of the following finished maps and charts has been completed, viz: general chart of the coast No. X, Straits of Florida, Key Biscayne to Marquesas Keys, $\frac{1}{400000}$; Tomales bay, Cal., $\frac{1}{30000}$, and various additions in topography and hydrography, constituting new editions, have been made to Boston harbor, Mass., $\frac{1}{40000}$; Port Royal entrance, Beaufort, Broad and Chechessee rivers, S. C., $\frac{1}{60000}$; Key West harbor, Fla., $\frac{1}{50000}$, and Washington sound, W. T., $\frac{1}{200000}$. In addition to these, four charts of our coast on a scale of $\frac{1}{1200000}$ have been engraved—No. 1, extending from Cape Sable to Sandy Hook; No. 4, from Mosquito inlet to Key West—and a chart of the Gulf coast in two sheets, extending from Key West to the Rio Grande. A new edition has also been engraved of Nantucket shoals, $\frac{1}{200000}$; a sketch of Cape Lookout shoals, N. C., $\frac{1}{80000}$, and important additions made to the chart of San Pablo bay, Cal., $\frac{1}{50000}$.

The following charts have been prepared for preliminary editions, viz: Rockland harbor, Me., $\frac{1}{20000}$; Hudson river from Poughkeepsie to Troy, $\frac{1}{40000}$, in two plates; Hampton Roads and Elizabeth river, Va., $\frac{1}{40000}$; St. Helena sound, S. C., $\frac{1}{40000}$; coast chart Nos. 69 and 70, Florida reefs, from The Elbow to New-found Harbor Keys, $\frac{1}{80000}$; western end of Florida reefs, including the Tortugas Keys, $\frac{1}{200000}$; main entrance to Charlotte harbor, Fla., $\frac{1}{40000}$, and Half-moon bay, Cal., $\frac{1}{20000}$.

Considerable progress has also been made upon the following important charts, viz: Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; coast charts Nos. 8, 10, and 11, scale $\frac{1}{80000}$, embracing portions of the coast from Portland, Me., to the extremity of Cape Cod, Mass.; Newport harbor, R. I., $\frac{1}{20000}$; Barnstable harbor, Mass., $\frac{1}{20000}$; coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$, as a finished chart; Hudson river, sheet No. 1, from entrance to Haverstraw, $\frac{1}{60000}$; Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{60000}$; and sheet No. 4, from Indian Head to Little Falls, $\frac{1}{40000}$; coast chart No 29, from Green Run inlet to Little Machipongo inlet, Md., $\frac{1}{80000}$; coast chart No. 48, from Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$; coast chart No. 53, from Stono inlet to Fripps's inlet, S. C., $\frac{1}{80000}$; Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$; coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{80000}$; upper part of San Francisco bay, Cal., $\frac{1}{50000}$; Pacific coast from Point Piños to Bodega Head, Cal., $\frac{1}{200000}$, and Bodega bay, Cal., $\frac{1}{30000}$.

And the following charts have been commenced, viz: coast chart No. 28, from Cape Henlopen, Del., to Green Run inlet, Md., $\frac{1}{80000}$; a sketch of entrance to Roanoke river, N. C., $\frac{1}{30000}$; coast chart No. 54, from Fripps's inlet to Ossabaw sound, Ga., $\frac{1}{80000}$; Beaufort river and inland passage from Port Royal to St. Helena sound, S. C., $\frac{1}{40000}$, and Wassaw sound, Ga., $\frac{1}{40000}$.

The engraving force has been principally employed as follows:

Mr. J. Knight, letter engraver, has engraved additional soundings and lettering upon coast chart No. 8, from Seguin island to Kennebunk Port, Me., $\frac{1}{80000}$; the soundings, bottoms, and lettering upon coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{80000}$; a portion of the soundings, general lettering, and the notes upon Hudson river No. 1, from entrance to Haverstraw, $\frac{1}{60000}$; various additions in hydrography, names and buoys upon coast charts Nos. 32 and 33, portions of Chesapeake bay, $\frac{1}{80000}$; the general lettering upon coast chart No. 53, Stono inlet to Fripps's inlet, S. C., $\frac{1}{80000}$; the title upon coast chart No. 100, Point au Fer to Marsh island, La., $\frac{1}{80000}$; the notes upon Gulf coast of the United States, eastern plate, $\frac{1}{1200000}$, and some additional lettering upon Pacific coast from Point Piños to Bodega Head, $\frac{1}{200000}$; and miscellaneous corrections and additions to various plates.

Mr. A. Rollé, topographical engraver, has completed the outlines and a portion of the topography upon coast chart No. 29, Green Run inlet to Little Machipongo inlet, Md., $\frac{1}{80000}$; a portion of the dry sand upon the new edition of Boston harbor, Mass., $\frac{1}{40000}$, and has commenced the topography upon coast chart No. 28, from Cape Henlopen, Del., to Green Run inlet, Md., $\frac{1}{80000}$.

Mr. J. Enthoffer, topographical engraver, has continued, upon contract, the topography upon coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$, upon which he is now engaged.

Mr. A. Sengteller, topographical engraver, has completed the outlines and is well advanced upon the topography of coast chart No. 53, Stono inlet to Fripps's inlet, S. C., $\frac{1}{80000}$, and engraved also a portion of the outlines of Rockland harbor, Maine, $\frac{1}{20000}$.

Mr. W. Phillips, topographical engraver, engraved the topography upon coast chart No. 69, Florida reefs, from The Elbow to Lower Matecumbe key, $\frac{1}{80000}$, and upon Tomales bay, Cal., $\frac{1}{30000}$; he engraved also the views for the plate of Pacific coast from Point Piños to Bodega Head, Cal., $\frac{1}{200000}$, and is now engaged upon the topography of Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$.

Mr. H. C. Evans, topographical engraver, has continued the topography upon coast chart No. 8, Seguin island to Kennebunk Port, Me., $\frac{1}{80000}$, and upon coast chart No. 11, Plymouth to Hyannis, Mass., $\frac{1}{80000}$; continued, also, Hudson river, sheet No. 1, from New York to Haverstraw, $\frac{1}{60000}$, and is at present engaged upon the additional topography upon Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$.

Mr. H. S. Barnard, topographical engraver, has engraved all the sand upon San Francisco bay, Cal., upper part, $\frac{1}{50000}$, and a portion of the sand upon Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; coast chart Nos. 69 and 70, Florida reefs, from The Elbow to Newfound Harbor keys, $\frac{1}{80000}$, and Pacific coast, from Point Piños to Bodega Head, Cal., $\frac{1}{200000}$, and corrections in sanding upon various plates.

Mr. A. M. Maedel, topographical engraver, has engraved a portion of the topography and outlines upon Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{60000}$, and upon sheet No. 4, from Indian Head to Little Falls, $\frac{1}{40000}$, and all the topography upon coast chart No. 48, from Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$.

Mr. J. C. Kondrup, miscellaneous engraver, engraved with the pantagraph a portion of the outlines upon chart of the Atlantic coast, sheet No. 1, Cape Sable to Sandy Hook, $\frac{1}{1200000}$; completed the outlines of coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{80000}$; the entire outlines of coast chart No. 54, Fripp's inlet to Ossabaw sound, Ga., $\frac{1}{80000}$; has ruled a tint upon the new edition of Washington sound, W. T., $\frac{1}{200000}$, and engraved a portion of the outlines upon the new edition of Boston harbor, Mass., $\frac{1}{40000}$.

Mr. E. A. Maedel, jr., letter engraver, engraved the title and completed the soundings upon Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; the title and notes upon Hudson river, sheet No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$; the titles of coast chart No. 70, Florida reefs, from Long key to Newfound Harbor key, $\frac{1}{80000}$, and of Hudson river, sheet No. 1, from New York to Haverstraw, $\frac{1}{60000}$; various additions in lettering and buoys to coast chart No. 32, Chesapeake bay, from Magothy river to Choptank river, $\frac{1}{80000}$; the general lettering, notes, and bottoms to charts of the Atlantic coast No. 1, Cape Sable to Sandy Hook, No. 4, Mosquito inlet to Key West, and of the Gulf coast, in two plates, from Key West to the Rio Grande, $\frac{1}{1200000}$, and is now engraving the title and notes upon coast chart No. 69, Florida reefs, from The Elbow to Lower Matecumbe key, $\frac{1}{80000}$.

Mr. A. Petersen, miscellaneous engraver, has engraved the soundings and general lettering of Potomac river, sheet No. 1, from entrance to Piney Point, $\frac{1}{60000}$; the shore-line, title, notes, and general lettering, complete, of two navy trial course plates, New York bay and Hampton Roads, $\frac{1}{40000}$; the title and lettering of St. Helena sound, S. C., $\frac{1}{40000}$; the title of Rockland harbor, Me., $\frac{1}{20000}$; the soundings and bottoms of coast chart No. 69, Florida reefs, from The Elbow to Lower Matecumbe key, $\frac{1}{80000}$, and the soundings, bottoms, and notes of coast chart No. 70, from Long key to Newfound Harbor key, $\frac{1}{80000}$.

Mr. R. F. Bartle, topographical engraver, has completed the marsh and grass upon Barnstable harbor, Mass., $\frac{1}{20000}$; a portion of the outlines of Rockland harbor, Me., $\frac{1}{20000}$; the sand on Potomac river, sheet No. 2, from Piney Point to Lower Cedar Point, $\frac{1}{60000}$, and Gulf coast of the United States, Key West to Rio Grande, in two sheets, $\frac{1}{1200000}$, and is now engaged upon the topography of James river from City Point to Richmond, including the Appomattox river, $\frac{1}{40000}$.

Mr. F. W. Benner, miscellaneous engraver, has engraved the sand of Rockland harbor, Me., $\frac{1}{20000}$, Mount Hope bay, R. I., $\frac{1}{40000}$; the shore-line, sand, and marsh of Hudson river, No. 4, from Glasco to Troy, $\frac{1}{40000}$; the outlines and topography of entrance to Roanoke river, N. C., $\frac{1}{30000}$, and a large amount of miscellaneous work, and is now engaged upon the marsh and sand of Hudson river, No. 3, from Poughkeepsie to Glasco, $\frac{1}{40000}$.

Mr. W. A. Thompson, topographical engraver, has completed the sand upon James river from City

Point to Richmond, $\frac{1}{40000}$; Calibogue sound and Skull creek, S. C., $\frac{1}{20000}$ and $\frac{1}{40000}$; western end of Florida reefs, including the Tortugas keys, $\frac{1}{200000}$, and Half-moon bay, Cal., $\frac{1}{20000}$; a portion of the sand upon coast chart No. 48, Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$; a portion of the outlines, all the sand, borders, curves, and compasses upon Atlantic coast of the United States, sheet No. 1, Cape Sable to Sandy Hook, and sheet No. 4, Mosquito inlet to Key West, $\frac{1}{1200000}$; and is now engaged upon the topography of Bodega bay, Cal., $\frac{1}{30000}$.

Mr. E. H. Sipe, miscellaneous engraver, has engraved various corrections and additions to Albemarle sound, N. C., $\frac{1}{200000}$; the bottoms, curves, &c., to St. Helena sound, S. C., $\frac{1}{40000}$; the outlines and lettering complete, of diagrams Girard College observations 1863; besides miscellaneous work upon various plates; and is now engaged upon the soundings, title, and notes of Nantucket shoals, $\frac{1}{200000}$, new edition.

Mr. J. G. Thompson, jr., miscellaneous engraver, engraved the outlines of Wassaw sound, Ga., $\frac{1}{40000}$; a portion of the notes of Hampton Roads, Va., $\frac{1}{40000}$; additional shore-line and lettering of Port Royal entrance, S. C., $\frac{1}{60000}$; the outlines and dry sand of St. Helena sound, S. C., $\frac{1}{40000}$; the notes of Rockland harbor, Me., $\frac{1}{20000}$; title and notes of Half-moon bay, Cal., $\frac{1}{20000}$; and is now engaged upon the outlines, title, and notes of Charlotte harbor, Fla., $\frac{1}{40000}$.

Mr. A. Buckle has punched the figures of soundings upon the following plates: Rockland harbor, Me., $\frac{1}{20000}$; entrance Roanoke river, N. C., $\frac{1}{30000}$; Navy Trial Course, two plates, New York bay and Hampton Roads, $\frac{1}{40000}$; coast chart No. 48, Barren inlet to Lockwood's Folly inlet, N. C., $\frac{1}{80000}$; St. Helena Sound, S. C., $\frac{1}{40000}$; Charlotte harbor, Fla., $\frac{1}{40000}$; Half-moon bay, Cal., $\frac{1}{20000}$; Atlantic coast of the United States, sheet No. 1, Cape Sable to Sandy Hook, $\frac{1}{1200000}$; Cape Lookout shoals, N. C., $\frac{1}{80000}$; Light-house inlet, S. C., $\frac{1}{20000}$, Hudson river, No. 4, from Poughkeepsie to Troy, $\frac{1}{40000}$; Beaufort river and Inland Passage, from Port Royal to St. Helena sound, S. C., $\frac{1}{40000}$, and a portion of the soundings upon Port Royal entrance, S. C., $\frac{1}{60000}$, and Wassaw sound, Ga., $\frac{1}{40000}$, besides some miscellaneous work and practice.

Mr. W. H. Davis has engraved the sailing directions and notes upon the new edition of Key West harbor, Fla., $\frac{1}{50000}$, and a portion of the notes for the new edition of Port Royal entrance, S. C., $\frac{1}{60000}$; the title, notes, and lettering of Cape Lookout shoals, N. C., $\frac{1}{80000}$; besides work upon progress sketches, and miscellaneous work and practice.

CATALOGUE OF HYDROGRAPHIC MAPS, CHARTS, AND SKETCHES PUBLISHED BY THE UNITED STATES COAST SURVEY TO NOVEMBER, 1864.

The maps and charts embraced in the following catalogue are of two general descriptions, which may be distinguished as *preliminary* and *finished*. The preliminary charts are those which are issued as soon after the several surveys as is consistent with accuracy of general delineation, and are designed to supply the immediate and pressing demands of navigation. The finished charts embody *all* the information furnished by the survey, including the minutest details; and embrace not only the hydrography, but the topography likewise. The two classes of charts differ in regard to the *amount* of the information which they furnish, but not in regard to the correctness of that which is given.

The charts are various in character, according to the objects which they are designed to subserve. The most important distinctions are the following:

1. *Sailing charts* upon a scale of $\frac{1}{1200000}$, embracing the largest area of any, and designed to enable the navigator to protract his course. Four of these cover the entire Atlantic coast of the United States. and two others embrace the entire coast of the Gulf of Mexico.

2. *General charts of the coast*, on a scale of $\frac{1}{400000}$, for off-shore navigation. These represent the shore-line and its characteristic features, so as to be readily recognized by the navigator approaching it. The entire Atlantic and Gulf coasts will be comprehended in sixteen charts of this class.

3. *Preliminary sea-coast charts*, on a scale of $\frac{1}{200000}$, for in-shore navigation. These will all be ultimately superseded by the more complete charts next to be named.

4. *Coast charts* for in-shore navigation, on a scale of $\frac{1}{80000}$, exhibiting with minute accuracy every natural and every permanent artificial feature, above or below the water, which can be introduced without occasioning confusion. They exhibit, also, the topography for some distance from the shore.

Besides the foregoing, there are numerous charts of harbors, bays, anchorages, &c., and sketches of local dangers, on various scales.

EXPLANATION OF THE SCALES.

A nautical mile contains 6,076 *feet, or* 72,912 *inches.*

Upon a scale of $\frac{1}{10000}$, a nautical mile is represented by $7\frac{3}{10}$ inches.
" " $\frac{1}{80000}$, " " " $\frac{9}{10}$ of an inch, nearly.
" " $\frac{1}{200000}$, " " " $\frac{3}{8}$ " " "
" " $\frac{1}{400000}$, " " " $\frac{3}{16}$ " " "
" " $\frac{1}{600000}$, " " " $\frac{1}{8}$ " " "
" " $\frac{1}{1200000}$, " " " $\frac{1}{16}$ " " "

The charts in the following Catalogue are arranged in geographical order, beginning at the northeastern boundary of the United States, and proceeding regularly along the coast of the Atlantic and Gulf of Mexico to the mouth of the Rio Grande; and afterwards beginning at San Diego bay, on the Pacific, and proceeding regularly northward to the northwestern boundary.

ATLANTIC COAST.

ABBREVIATIONS.—F., Finished; Pr., Preliminary; Sk., Sketch.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
SAILING CHARTS.				
Atlantic coast of the United States:		*Inches.*		
I. Cape Sable to Sandy Hook	Pr.	24 × 28	$\frac{1}{1,200,000}$	1864
II. Nantucket to Cape Hatteras	Pr.	24 × 28	do.	1864
III. Cape Hatteras to Mosquito inlet	Pr.	24 × 28	do.	1864
IV. Mosquito inlet to Key West, with Bahama Banks	Pr.	24 × 28	do.	1864
Gulf coast of the United States:				
Key West to Rio Grande	Pr.	28 × 52	do.	1864
GENERAL CHARTS OF THE COAST.				
No. III. From Gay Head to Cape Henlopen	F.	31 × 38½	$\frac{1}{400,000}$	1852
No. IV. From Cape May to Cape Henry	Pr.	31 × 38	do.	1863
No. X. Straits of Florida, from Key Biscayne to Marquesas keys	Pr.	31 × 38	do.	1860
COAST AND HARBOR CHARTS.				
Eastport harbor	Pr.	17 × 20	$\frac{1}{40,000}$	1864
Sea-coast chart, No. 3, Small Point, Me., to Cape Cod, Mass	Pr.	31 × 37	$\frac{1}{200,000}$	1859
Eggemoggin Reach	Sk.	9 × 11	$\frac{1}{20,000}$	1854
Rockland harbor	Pr.	19 × 21	do.	1863
Rockport and Camden harbors	Pr.	14 × 17	do.	1864
Kennebec and Sheepscot rivers	Pr.	23½ × 38½	$\frac{1}{40,000}$	1863
Casco bay, approaches to Portland	Pr.	21 × 30½	$\frac{1}{80,000}$	1863
Portland harbor	F.	26 × 29	$\frac{1}{20,000}$	1862
Richmond's Island harbor	F.	14 × 17	do.	1851

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
Portland harbor, showing wharf line recommended by city commissioners	Sk.	20½ × 22	$\frac{1}{10,000}$	1855
York River harbor	F.	12½ × 16	$\frac{1}{20,000}$	1854
Portsmouth harbor	Pr.	19 × 27	do.	1854
Isles of Shoals	F.	14 × 17	do.	1864
Newburyport harbor	F.	17 × 24½	do.	1855
Ipswich and Annisquam harbor	F.	19 × 29	do.	1857
Rockport harbor	F.	14 × 17½	do.	1859
Gloucester harbor	F.	14 × 18	do.	1855
Salem harbor	F.	21 × 28	$\frac{1}{25,000}$	1859
Lynn harbor	F.	14½ × 17½	$\frac{1}{20,000}$	1859
Boston harbor	F.	28½ × 36	$\frac{1}{40,000}$	1857
Boston bay and approaches	Pr.	30 × 29	$\frac{1}{80,000}$	1864
Sea-coast Chart, No. 4, from Cape Cod, Mass., to Saughkonnet Point, R. I.	F.	29½ × 31½	$\frac{1}{200,000}$	1857
Plymouth harbor	F.	19½ × 23	$\frac{1}{20,000}$	1857
Barnstable harbor	Pr.	16½ × 23	do.	1861
Wellfleet harbor	F.	14 × 17½	$\frac{1}{50,000}$	1853
Provincetown harbor	F.	14½ × 17½	do.	1857
Nantucket shoals	Pr.	23½ × 19½	$\frac{1}{200,000}$	1863
Coast from Monomoy and Nantucket shoals to Block island, (in three sheets,) viz:				
1. From Monomoy and Nantucket shoals to Muskeget channel, Mass., Coast Chart, No. 12.	F.	27½ × 37½	$\frac{1}{80,000}$	1860
2. From Muskeget channel to Buzzard's bay and entrance to Vineyard sound, Mass., Coast Chart, No. 13.	F.	do.	do.	1860
3. From entrance to Buzzard's bay to Block island, R. I., Coast Chart, No. 14	F.	do.	do.	1860
Bass River harbor	F.	13½ × 16½	$\frac{1}{40,000}$	1857
Hyannis harbor	F.	14½ × 18½	$\frac{1}{30,000}$	1850
Nantucket harbor	F.	14 × 17	$\frac{1}{20,000}$	1848
Muskeget channel	F.	21 × 28	$\frac{1}{60,000}$	1859
Edgartown harbor	F.	14½ × 17½	$\frac{1}{20,000}$	1848

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
Holmes's Hole and Tarpaulin Cove harbors	F.	14 × 17½	$\frac{1}{20,000}$	1847
Wood's Hole harbor	F.	13 × 17½	do.	1857
Sippican harbor	Pr.	14½ × 18	do.	4864
New Bedford harbor	F.	14¼ × 18	$\frac{1}{40,000}$	1850
Mount Hope bay	Pr.	16 × 19	do.	1861
Bristol bay	Pr.	13 × 17	$\frac{1}{20,000}$	1863
Newport harbor	Pr.	13 × 17	do.	1863
Dutch island	F.	14½ × 17½	$\frac{1}{10,000}$	1863
Long Island sound, (in three sheets,) viz:				
1. Eastern part, Coast Chart, No. 15	F.	25½ × 35½	$\frac{1}{80,000}$	1855
2. Middle part, Coast Chart, No. 16	F.	do.	do.	1855
3. Western part, Coast Chart, No. 17	F.	do.	do.	1855
Fisher's Island sound	F.	14 × 17½	$\frac{1}{40,000}$	1847
New London harbor	F.	14 × 17½	$\frac{1}{20,000}$	1848
Mouth of Connecticut river	F.	14 × 17½	do.	1853
Hart and City islands and Sachem's Head harbors	F.	14 × 17½	$\left\{\begin{array}{c}\frac{1}{20,000}\\ \frac{1}{10,000}\end{array}\right\}$	1851
New Haven harbor	F.	14 × 17½	$\frac{1}{30,000}$	1846
Black Rock and Bridgeport harbors	F.	14 × 17½	$\frac{1}{20,000}$	1848
Sheffield Island and Cawkin's Island harbors	F.	14 × 17½	do.	1848
Captain's islands, East and West harbors	F.	14 × 17½	do.	1849
Hempstead harbor	F.	14½ × 18	do.	1859
Oyster or Syosset Bay harbor	F.	14 × 17½	$\frac{1}{30,000}$	1847
Huntington bay	F.	14 × 17½	$\frac{1}{300,000}$	1849
Southern coast of Long Island, (in three sheets,) viz:				
1. Eastern part, Coast Chart, No. 18	F.	25 × 35	$\frac{1}{80,000}$	1857
2. Middle part, Coast Chart, No. 19	F.	do.	do.	1857
3. Western part, Coast Chart, No. 20	F.	do.	do.	1851

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
Hell Gate and approaches	F.	25 × 36	$\frac{1}{5,000}$	1851
New York bay and harbor	Pr.	27 × 31	$\frac{1}{80,000}$	1861
Hudson river, (in three sheets,) viz:				
No. 1. New York to Haverstraw	F.	17½ × 40	$\frac{1}{60,000}$	1863
No. 2. Haverstraw to Poughkeepsie	Pr.	17½ × 40	do.	1861
No. 3. Poughkeepsie to Troy	Pr.	34 × 40	$\frac{1}{40,000}$	1863
Little Egg harbor	F.	14 × 17½	$\frac{1}{30,000}$	1846
Absecom inlet	F.	14½ × 17½	$\frac{1}{20,000}$	1864
Delaware bay and river, (in three sheets,) viz:				
1. (Upper,) Coast Chart, No. 25	F.	25¼ × 36	$\frac{1}{80,000}$	1848
2. (Middle,) Coast Chart, No. 26	F.	do.	do.	1848
3. (Entrance,) Coast Chart, No. 27	F.	do.	do.	1848
Delaware and Chesapeake bays	Pr.	25½ × 31	$\frac{1}{400,000}$	1855
Sea-coast Chart, No. 8; sea-coast of Delaware, Maryland, and part of Virginia	Pr.	20 × 28	$\frac{1}{200,000}$	1852
Sea-coast Chart, No. 9; sea-coast of Virginia and entrance to Chesapeake bay	Pr.	21 × 28	do.	1855
Chincoteague inlet	Sk.	14 × 17½	$\frac{1}{40,000}$	1852
Metompkin inlet	Sk.	19½ × 21½	$\frac{1}{20,000}$	1862
Wachapreague, Machipongo, and Metompkin inlets	Sk.	12½ × 16	$\frac{1}{40,000}$	1853
Ship and Sand Shoal inlets	Pr.	14 × 17	do.	1854
Chesapeake bay, (in six sheets,) viz:				
1. From head of bay to mouth of Magothy river, Coast Chart, No. 31	F.	30 × 37½	$\frac{1}{80,000}$	1863
2. From Magothy river to Choptank river, Coast Chart, No. 32	F.	30 × 37½	do.	1863
3. From Choptank river to the Potomac river, Coast Chart, No. 33	F.	30 × 37½	do.	1863
4. From the Potomac river to Pocomoke sound, Coast Chart, No. 34	F.	26 × 38	do,	1863
5. From Pocomoke sound to York river, Coast Chart, No. 35	F.	26 × 38	do.	1863
6. From York river to entrance, Coast Chart, No. 36	F.	26 × 38	do.	1863
Cherrystone inlet	Sk.	9 × 13	$\frac{1}{40,000}$	1853
Pungoteague creek	Sk.	8½ × 10½	do.	1853

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
Mouth of Chester river	F.	14 × 17½	$\frac{1}{40,000}$	1849
Patapsco river	F.	17½ × 27½	$\frac{1}{60,000}$	1859
Annapolis harbor	F.	14 × 17½	do.	1846
Patuxent river, (lower)	Pr.	19 × 22½	do.	1859
Patuxent river, Point Judith to Nottingham	Pr.	18 × 31½	$\frac{1}{30,000}$	1860
Potomac river, (in four sheets,) viz:				
1. Entrance to Piney Point	Pr.	23 × 29½	$\frac{1}{60,000}$	1862
2. Piney Point to Lower Cedar Point	Pr.	23 × 29½	do.	1862
3. Lower Cedar Point to Indian Head	Pr.	23 × 29½	do.	1862
4. Indian Head to Little Falls bridge	Pr.	23 × 39	$\frac{1}{40,000}$	1862
Rappahannock river, (in six sheets,) viz:				
1. From Fredericksburg to near Moss Neck	F.	17 × 29	do.	1862
2. From Moss Neck to Port Royal	F.	do.	do.	1862
3. From Port Royal to Saunders's wharf	Pr.	do.	$\frac{1}{20,000}$	1862
4. From Saunders's wharf to Occupacia creek	Pr.	do.	do.	1862
5. From Occupacia creek to Deep creek	F.	do.	do.	1862
6. From entrance to Deep creek	F.	do.	do.	1862
York river, Va., (in two sheets,) viz:				
1. From King's creek to West Point	F.	17 × 23	$\frac{1}{60,000}$	1858
2. From entrance to King's creek	F.	do.	do.	1857
Pamunky and Mattapony rivers	Sk.	14½ × 18	do.	1862
James river, (in two sheets,) viz:				
1. From Richmond to City Point	Pr.	28 × 30	$\frac{1}{40,000}$	1855
2. From entrance to City Point	Pr.	28 × 41	$\frac{1}{30,000}$	1859
Hampton Roads and Elizabeth river	Pr.	16 × 22	$\frac{1}{40,000}$	1857
Norfolk harbor	Pr.	16 × 20	$\frac{1}{10,000}$	1857
Atlantic coast, from entrance of Chesapeake bay to Ocracoke inlet	Sk.	17 × 28	$\frac{1}{400,000}$	1862

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
North Landing river	F.	17 × 21	1/40,000	1861
Pasquotank river	F.	14 × 17½	1/60,000	1850
Albemarle sound, (in one sheet)	Pr.	15½ × 22	1/200,000	1855
Albemarle sound, (in two sheets,) viz:				
1. Western part, Coast Chart, No. 40	F.	29¾ × 31½	1/80,000	1860
2. Eastern part, Coast Chart, No. 41	F.	do.	do.	1860
Mouth of Roanoke river	Sk.	19 × 21	1/30,000	1863
Oregon inlet	Sk.	16 × 17½	1/20,000	1863
Wimble shoals	Sk.	7 × 8	1/80,000	1854
Hatteras shoals	Sk.	11¼ × 11¼	1/120,000	1850
Hatteras inlet	Pr.	15 × 17	1/20,000	1861
Ocracoke inlet	Pr.	14 × 14½	1/40,000	1852
Cape Lookout shoals	Sk.	17½ × 20½	1/80,000	1864
Beaufort harbor	F.	23 × 30	1/20,000	1857
Beaufort harbor, (new edition)	Pr.	18½ × 19½	do.	1864
Core sound	Pr.	19 × 33	1/40,000	1864
New river and bar	Sk.	14 × 17	1/15,000	1852
Cape Fear and approaches, including the river to Wilmington, Coast Chart, No. 48	F.	32 × 40	1/80,000	1864
Cape Fear river and Frying Pan shoals	F.	26 × 30½	1/30,000	1857
Cape Fear river, from Federal Point to Wilmington	F.	26 × 30½	do.	1856
Winyah bay and Georgetown harbor	Pr.	17½ × 25½	1/40,000	1855
Winyah bay and Cape Roman shoals	Pr.	14 × 21½	1/100,000	1854
Sea-coast Chart, No. 14, Cape Roman to Tybee island	F.	32 × 38½	1/200,000	1857
Bull's bay	Pr.	17 × 23	1/60,000	1859
Charleston harbor	F.	31½ × 32	1/30,000	1864
Light-house inlet	Sk.	10 × 20½	1/20,000	1864
Stono inlet	Pr.	19½ × 21	1/20,000	1862

Coast and Harbor Charts—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
North Edisto river	Pr.	14 × 17½	1/50,000	1862
St. Helena sound	Pr.	24 × 28	1/40,000	1862
Port Royal entrance, Beaufort, Chechessee, and Colleton rivers	Pr.	22½ × 29½	1/60,000	1862
Beaufort river and inside passage between Port Royal and St. Helena sounds	Pr.	24½ × 28	1/40,000	1864
Calibogue sound and Skull creek	Pr.	22 × 28	{1/40,000 ; 1/20,000}	1862
Savannah river	Pr.	20 × 33	1/40,000	1862
Wassaw sound	Pr.	20 × 33	do.	1863
Ossabaw sound	F.	24 × 37	1/30,000	1860
Romerly marshes	Pr.	16½ × 29	1/10,000	1855
Sapelo sound	F.	23 × 34	1/30,000	1859
Doboy bar and inlet	Sk.	12 × 15	1/40,000	1855
St. Simon's sound, Brunswick harbor, and Turtle river	F.	19 × 29	do.	1862
St. Andrew's shoals	Sk.	11 × 12	1/60,000	1850
Atlantic coast, Savannah river to St. Augustine	Sk.	23 × 35	1/200,000	1861
St. Mary's river and Fernandina harbor	F.	25 × 32	1/20,000	1857
St. John's river, (in two sheets,) viz:				
1. From entrance to Brown's creek	F.	19½ × 23	1/25,000	1856
2. From Brown's creek to Jacksonville	F.	19½ × 27	do.	1856
St. Augustine harbor	F.	21 × 22	1/30,000	1860
Mosquito inlet	Sk.	7 × 8	1/40,000	1851
Cape Canaveral shoals	Sk.	15½ × 20	1/60,000	1850

COAST OF THE GULF OF MEXICO.

Sea-coast Chart, Key Biscayne to Pickle's reef	Pr.	12½ × 19	1/200,000	1856
Florida reefs, (in four sheets,) viz:				
1. From Key Biscayne to Carysfort reef, Coast Chart, No. 68	F.	32 × 39	1/80,000	1861
2. From the Elbow to Matacumbe key, Coast Chart, No. 69	F.	32 × 39	do.	1863

Coast of the Gulf of Mexico—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
3. From Long key to Newfound Harbor key, Coast Chart, No. 70	F.	32 × 39	$\frac{1}{80,000}$	1863
4. Newfound Harbor key to Boca Grande key, Coast Chart, No. 71	F.	32 × 39	do.	1859
Western end of Florida reefs, Key coast to Tortugas	Pr.	17½ × 28	$\frac{1}{200,000}$	1863
Beacons on Florida reefs	Sk.	15¼ × 20	$\frac{1}{400,000}$	1860
Legaré anchorage	Pr.	22 × 22¼	$\frac{1}{20,000}$	1857
Turtle harbor	Sk.	8 × 9½	$\frac{1}{40,000}$	1854
Coffin's patches	Sk.	11 × 11½	$\frac{1}{20,000}$	1854
Key West harbor	F.	24 × 34	$\frac{1}{50,000}$	1863
Charlotte harbor	Pr.	22 × 27	$\frac{1}{40,000}$	1864
Tampa bay	Sk.	17 × 21½	$\frac{1}{120,000}$	1855
Waccasassa bay	Pr.	18 × 18	$\frac{1}{50,000}$	1856
Cedar keys	Pr.	19½ × 26	do.	1861
Ocilla river	Sk.	10 × 13	$\frac{1}{20,000}$	1855
St. Mark's river	Pr.	18 × 27	$\frac{1}{30,000}$	1856
St. George's sound, western part, (embracing Apalachicola harbor)	Pr.	23½ × 34	$\frac{1}{40,000}$	1860
St. George's sound, eastern part	Pr.	23 × 34	do.	1859
St. Andrew's bay	Pr.	17½ × 19	do.	1855
Escambia and Santa Maria de Galvaez bays	Pr.	26 × 31½	$\frac{1}{30,000}$	1861
Pensacola bay, entrance to	F.	25½ × 32	$\frac{1}{20,000}$	1859
Sea-coast Chart, No. 26; part of Alabama and Mississippi	Pr.	20 × 27	$\frac{1}{200,000}$	1857
Mobile bay, entrance to	F.	19 × 28½	$\frac{1}{40,000}$	1851
Mobile bay, Coast Chart, No. 90	F.	29 × 38	$\frac{1}{80,000}$	1856
Mississippi sound, eastern part, Coast Chart, No. 91	F.	31½ × 40¼	do.	1860
Mississippi sound, western part, Coast Chart, No. 92	F.	32 × 41½	do.	1860
Horn Island pass	Pr.	12 × 16	$\frac{1}{40,000}$	1853
Pascagoula River entrance	Sk.	10½ × 13	$\frac{1}{20,000}$	1853

Coast of the Gulf of Mexico—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
Cat and Ship Island harbors	F.	17 × 34	$\frac{1}{40,000}$	1850
Biloxi bay	Pr.	14 × 17	do.	1858
Pass Christian harbor	Sk.	9 × 11	do.	1851
Pass à l'Outre, Mississippi delta	Sk.	18 × 21	$\frac{1}{20,000}$	1860
The delta of the Mississippi, reconnaissances of the passes	Sk.	13½ × 21	$\frac{1}{60,000}$	1852
Southwest pass of the Mississippi	Sk.	15 × 19	$\frac{1}{20,000}$	1862
Barataria Bay entrance	Sk.	14 × 17½	$\frac{1}{30,000}$	1853
Pass Fourchon	Sk.	7 × 10	$\frac{1}{10,000}$	1854
Timballier Bay entrance	Sk.	11 × 16½	$\frac{1}{20,000}$	1853
Ship Island shoal	Sk.	16 × 17½	$\frac{1}{80,000}$	1853
Atchafalaya bay	Pr.	26½ × 31	$\frac{1}{50,000}$	1858
Vermillion bay and Calcasieu river	Sk.	11 × 13	$\left\{\frac{1}{40,000}\right\}$ $\left\{\frac{1}{30,000}\right\}$	1855
Sabine pass	Sk.	9 × 11	$\frac{1}{40,000}$	1853
Galveston entrance	F.	14 × 17	do.	1856
Sea-coast Chart, No. 30, Galveston bay	Pr.	17 × 20	$\frac{1}{200,000}$	1855
Sea-coast Chart, No. 31, Galveston bay to Matagorda bay	Pr.	32 × 36½	do.	1857
Galveston bay to Oyster bay, Coast Chart, No. 106	Pr.	32½ × 40	$\frac{1}{80,000}$	1858
Oyster bay to Matagorda bay, Coast Chart, No. 107	Pr.	32 × 40	do.	1858
San Luis pass	Pr.	14 × 17	$\frac{1}{20,000}$	1853
Brazos River entrance	Pr.	15½ × 18	$\frac{1}{10,000}$	1858
Matagorda and Lavaca bays	Pr.	25 × 42	$\frac{1}{40,000}$	1857
Coast of Texas between Matagorda and Corpus Christi—reconnaissance	Pr.	20 × 24	$\frac{1}{1,200,000}$	1858
Aransas pass	Sk.	9½ × 12½	$\frac{1}{20,000}$	1853
Rio Grande entrance	Pr.	14 × 16	do.	1854

PACIFIC COAST.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
Western coast of the United States, reconnaissance of, (in three sheets,) viz:				
1. From San Diego to San Francisco	Pr.	*Inches.* 22 × 23	$\frac{1}{1,200,000}$	1853
2. From San Francisco to Umquah river	Pr.	22½ × 25	do.	1854
3. From Umpquah river to the boundary	Pr.	do.	do.	1855
San Diego bay	F.	20 × 27	$\frac{1}{40,000}$	1859
Cortez Bank	Sk.	13½ × 18½	$\frac{1}{80,000}$	1856
San Clemente, Prisoners' and Cuyler's harbors	Sk.	14 × 17½	$\frac{1}{20,000}$	1852
Anacapa island and eastern part of Santa Cruz island	Pr.	9½ × 26½	$\frac{1}{30,000}$	1856
San Pedro anchorage and vicinity of Santa Barbara	Sk.	8 × 15	$\left\{\begin{array}{c}\frac{1}{20,000}\\ \frac{1}{40,000}\end{array}\right\}$	1855
San Pedro harbor	Pr.	12½ × 16	$\frac{1}{30,000}$	1852
Santa Barbara	Sk.	14 × 17	$\frac{1}{20,000}$	1853
Eastern entrance to Santa Barbara channel	Pr.	16½ × 23½	$\frac{1}{80,000}$	1857
Point Conception	Sk.	7 × 7½	$\frac{1}{40,000}$	1850
Santa Cruz, San Simeon, Coxo, and San Luis Obispo harbors—reconnaissance	Sk.	13½ × 17½	$\frac{1}{20,000}$	1852
Point Pinos	Sk.	7½ × 9	do.	1851
Pacific coast, from Point Pinos to Bodega head	Pr.	28 × 39	$\frac{1}{200,000}$	1862
Monterey harbor	Pr.	12 × 13	$\frac{1}{40,000}$	1852
Monterey bay	Pr.	20½ × 31	$\frac{1}{60,000}$	1857
Santa Cruz and Año Nuevo harbors	Pr.	12½ × 12½	$\frac{1}{40,000}$	1854
Half-Moon bay	Pr.	18½ × 20	$\frac{1}{20,000}$	1863
San Francisco bay entrance	F.	24 × 39	$\frac{1}{50,000}$	1859
San Pablo bay	F.	24 × 39	do.	1860
Petaluma and Napa creeks	Pr.	21 × 30	$\frac{1}{30,000}$	1861
Mare Island straits	F.	14½ × 18	do.	1863
San Francisco bay, upper part	Pr.	27 × 36	$\frac{1}{50,000}$	1862

Pacific Coast—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
City of San Francisco	Pr.	24 × 35	$\frac{1}{10,000}$	1857
Point Reyes and Drake's bay	Sk.	9 × 10	$\frac{1}{40,000}$	1855
Drake's bay	Pr.	19½ × 30	do.	1860
Bodega bay	Pr.	13 × 17	$\frac{1}{30,000}$	1862
Tomales bay	Pr.	15½ × 24½	do.	1861
Humboldt bay	Pr.	14 × 17½	do.	1858
Trinidad bay	Sk.	8¼ × 10½	$\frac{1}{20,000}$	1851
Crescent City harbor	F.	12 × 16	do.	1859
Port Orford, Shelter cove, Mendocino City, and Crescent City harbor	Sk.	14 × 18	do.	1854
Coquille River entrance	Pr.	14¼ × 20½	$\frac{1}{10,000}$	1861
Koos bay	F.	15 × 18	$\frac{1}{20,000}$	1861
Umquah River entrance	Pr.	13 × 17	do.	1854
Columbia River entrance	Pr.	13¾ × 14	$\frac{1}{40,000}$	1854
Cape Hancock	Sk.	7 × 8	$\frac{1}{20,000}$	1851
Shoalwater bay	Pr.	17 × 25	$\frac{1}{80,000}$	1856
Gray's harbor	Pr.	16½ × 17	$\frac{1}{40,000}$	1862
Cape Flattery and Nee-ah harbors	F.	14 × 17	do.	1853
False Dungeness and New Dungeness	Sk.	10 × 23	$\left\{\begin{matrix}\frac{1}{30,000}\\ \frac{1}{40,000}\end{matrix}\right\}$	1853 1856
Port Townshend	Sk.	11½ × 14½	$\frac{1}{40,000}$	1858
Smith's or Blunt's island	Sk.	6¼ × 9½	$\frac{1}{20,000}$	1854
Port Ludlow	Pr.	11 × 14½	do.	1856
Port Gamble	Pr.	16 × 23	do.	1858
Duwamish bay and Seattle harbor	Sk.	8 × 10	$\frac{1}{40,000}$	1854
Steilacoom harbor	Sk.	12 × 16	$\frac{1}{30,000}$	1856
Olympia harbor	Sk.	10½ × 12½	$\frac{1}{20,000}$	1856

Pacific Coast—Continued.

TITLE.	Class.	Size of border.	Scale.	Date of last edition.
		Inches.		
Washington sound	Pr.	$25\frac{1}{2} \times 27$	$\frac{1}{200,000}$	1863
Blakely harbor	Sk.	$11\frac{1}{2} \times 15\frac{1}{2}$	$\frac{1}{10,000}$	1856
Bellingham bay	Sk.	$14 \times 16\frac{1}{2}$	$\frac{1}{40,000}$	1856
Semi-ah-moo bay	Sk.	$11\frac{1}{2} \times 16\frac{1}{2}$	$\frac{1}{30,000}$	1858

ELECTROTYPE AND PHOTOGRAPH DIVISION.—This branch of the work has continued under the direction of Mr. George Mathiot. During the first half of the year he was assisted by Mr. A. Zumbrock, and since then he has performed the work of the division without an assistant

The electrotype process has been applied, as heretofore, to the duplication of the engraved plates and the compounding of separately engraved parts of plates. Thirty-two plates, of which seventeen were "altos" and fifteen "bassos," were made during the year.

The use of photography for reducing the original surveys to the publication scales, and for duplicating drawings for other departments of the government, has been continued. During the year twenty-eight glass "positives," eighty-seven glass "negatives," and seven hundred and forty-six paper prints, mostly of large size, have been made from seventy-eight original drawings. The appended tables state in detail the work performed in this division:

Table of electrotypes made during the year ending October 1, 1864.

ALTOS.	BASSOS.
Rappahannock river, sheet No. 2.	Atlantic coast, sheet No. 2.
Atlantic coast, sheet No. 2.	Rappahannock river, sheet No. 1.
San Francisco bay.	Key West harbor.
Atlantic coast, sheet No. 3.	Atlantic coast, sheet No. 3.
Chesapeake bay, sheet No. 6.	Rappahannock river, sheet No. 2.
Coast Chart, No. 4.	Chesapeake bay, sheet No. 6, (bis.)
Saint John's river.	Coast Chart, No. 10.
Coast Chart, No. 10.	San Francisco bay.
Atlantic coast, sheet No. 4.	Chesapeake bay, sheet No. 5.
Chesapeake bay, sheet No. 5.	Atlantic coast, sheet No. 4.
James river, sheet No. 2.	Chesapeake bay, sheet No. 3.
Nantucket shoals.	York river, (entrance.)
Chesapeake bay, sheet No. 3.	Boston harbor.
Nantucket shoals, (new edition.)	Nantucket shoals.
Gulf coast, (east half.)	Saint John's river.
Gulf coast, (west half.)	
Chesapeake bay, sheet No. 4.	

Objects photographed.	Positives.	Negatives.	Prints.
Drawing of a rebel ram		6	49
Six drawings of rebel works at Vicksburg		1	5
Drawing, map of Rockbridge county, Virginia			6, 2 in. to 1 mile
Twelve maps of Washington and vicinity		1	179, 2 in. to 1 mile
Drawings, specimens of topographical drawing		1	9
Tracing, Guyot's mountains of Tennessee			4
Drawing of Grand Gulf, Mississippi		2	24
Drawing showing the organization of the Sanitary Commission		1	4
Maps, Georgia from Atlanta to Augusta		1	4
Two maps of western South Carolina and Georgia		2	8
Tracing, map of Rockland harbor	2 of 1–20,000		
Road map showing the approaches to Washington, D. C		6	42
Coast chart No. 10, 13 tracings	6 of 1–80,000	23	26 of 1–80,000
Three tracings for chart Tomales bay, California	3 of 1–30,000		
Tracing, Ossabaw sound, Georgia	1 of 1–10,000	1 of 1–10,000	2 of 1–10,000
Drawing of proposed sailing compasses for the monitors		2	12, ⅓ of original
Three tracings for coast chart No. 11	1 of 1–80,000	2 of 1–80,000	4 of 1–80,000
Tracing part of Boston harbor		1	2 of 1–40,000
Two tracings for map of Henrico county, Virginia		1	120, 2 in. to 1 mile
Plane-table sheet of the city of Richmond	1 of 1–10,000		
Views of pontoon bridges			38
Map of Cumberland, Maryland		1	5, reduced one-half
Sketch showing the relative positions of coast charts Nos. 68, 69, 70, 71	1	1	2, 1–10 of original
Drawing, map of Appomatox river, from City Point to Petersburg		1	18 of 1–20,000
Plans of the battles of Saline cross-roads		1	6, ⅔ of original
Maps of the survey of the Pacific railroad, California		5	42
Maps of the James river, from City Point to Richmond		2	42
Projects to prevent counterfeiting treasury notes by photography		5	10
Two plane-table sheets of the Appomatox river		2	8
Maps of Carrol and Howard counties, Maryland			17
Tracing, map of the Mississippi river from Rodney to Sargent's bend	3	2	
Drawing showing compass variations on the steamer Roanoke		1	2
Six maps of the northwest boundary of the United States		6	42
Four tracings for coast chart No. 53			8 of 1–40,000
One tracing for coast chart No. 8	1	1	2 of 1–80,000
One tracing for coast chart No. 47	1 of 1–80,000	2	2 of 1–80,000
Three tracings for coast chart No. 54	6 of 1–80,000	2	4 of 1–10,000
One tracing for chart of Bodega bay, California	1 of 1–30,000	1	1 of 1–30,000
One tracing for chart of Casco bay	1	1	1 of 1–10,000
Three tracings for chart of Hudson river	6 of 1–60,000	3	3 of 1–60,000
Three tracings for chart of Sheepscot river	4 of 1–80,000		

LITHOGRAPHING DIVISION.—The details of work in this division were directed until the 1st of June by *Professor F. A. P. Barnard.* On his acceptance of the presidency of Columbia College, they were devolved, together with the supervision of the map printing, upon *Mr. W. W. Cooper,* in addition to usual duties, of which he still remains in charge, in the office of the superintendent.

When this section of the office was organized, the outfit for lithographing was adapted merely to the occasion, connected with increase of the navy, which very largely raised the demand for copies of coast charts, and particularly of such as were needed in blockade duty. In the course of the war, however, much material of public interest came in, furnished in part by our topographers associated for duty with the armies, and partly by the military engineers. To make such matter further available for the public service, facilities for publication have been added from time to time, and data of importance can now be embodied at once, either with some of the military maps already provided in the division or prepared in a separate form, as may be most desirable. The engravings on stone being, moreover, of a uniform scale for a very large part of the southern States, any limits for a special map may be chosen at pleasure, and a sheet issued promptly when needed in prospective military movements. This remark applies to the area of all the States in rebellion east of the Mississippi river, excepting the back districts of North and South Carolina, and the neutral part of Tennessee and to southern Florida, in which no military movements have taken place.

Much of the effectiveness of style in the maps already published, and their completeness in respect of attainable data, are due to the intelligent interest given to the work by Professor Barnard while he was temporarily in charge of the division.

The special maps drawn this year by *Mr. A. Lindenkohl,* and by *Mr. H. Lindenkohl,* previous to the end of August, when he retired from the office, comprise the greater part of the States of Virginia, Georgia, Alabama, Mississippi, and Florida, and parts of North and South Carolina and of Tennessee. Divided and recombined in various ways, these drawings have all been published, to serve as military maps, and as such they have been in requisition with the two armies under command of Lieutenant General Grant and Major General Sherman.

The lithographic engraving has been done, as heretofore, by *Mr. C. G. Krebs*, and, in addition, much of his time and that of *Mr. H. Lindenkohl* has been given to the adjustment of supplementary material in the extension or correction of hydrographic charts, and in the revision of military maps, with a view of combining the latest information in successive editions. In the beginning of the present working year *Mr. Edward Molitor* was temporarily attached to the division as engraver, and also for a short period in September last.

Transfers have been made during the year from fifty-four of the engraved copper plates of the office, and from sixty-four lithographic engravings, exclusive of thirty-seven offsets, for printing in color. The transfers from copper and thirty-five of the others were made by *Mr. Arch'd Brown*, the remainder by *Mr. James Ruhl.*

Several of our hydrographic charts have been issued from the division with distinctive color to mark the parts covered by shoal water. This expedient promises well as a substitute for the engraved "sanding," and is specially adapted to the ready publication of charts in their complete form.

The military maps before referred to have been prepared for color-printing, and range from one to as many as five colors on a single sheet. The statistics of these and of the printing from copper plate transfers will be stated under the next head.

The titles of the maps drawn and engraved on stone during the present year are given in a summary of office-work in the introductory part of the Superintendent's report.

MAP PRINTING.—In the lithographic division, seventeen thousand four hundred and eighty-nine copies of the hydrographic charts of the Coast Survey have been printed from transfers during the year on two presses by *Mr. Brown* and *Mr. Ruhl.* The copper plate press of the office, worked by *Mr. John Rutherdale*, has furnished ten thousand two hundred and seventy-eight copies, exclusive of fourteen hundred and ninety-two chart proofs taken for the engraving division; and fifteen thousand eight hundred and five copies of hydrographic charts were printed by the transfer process out of the office.

The aggregate of charts printed during the year for distribution is forty-three thousand five hundred and seventy-two.

In the lithographic section twelve thousand one hundred and twenty-five copies of military maps have been printed Most of the sheets being in colors, twenty-seven thousand two hundred and ninety-five impressions were required. Nearly nine hundred copies of maps so produced were of five colors; eight hundred of four colors; more than two thousand were of three colors; and over five thousand copies were issued in two colors.

Including six thousand sheets of various kinds of circulars for official use, the two lithographic presses have given an aggregate of nearly fifty-one thousand impressions during the year.

In order to keep up with the demand for war maps, it has been necessary in several instances to send to other printing offices for the press-work, transfers from our lithograph edengravings. The number of sheets received in that way during the year was ten thousand two hundred. These added to the number printed in the section make a total of twenty-two thousand three hundred and twenty-five copies, and, with the hydrographic charts, an aggregate of sixty-five thousand eight hundred and ninety-seven sheets, exclusive of proofs and circulars, of which the number printed was upward of seven thousand.

Distribution of maps and annual reports.—The charge of the map-room has continued with *Mr. M. T. Johnstone*, and, as will be seen by his returns, a larger distribution has been made during the present year than in any preceding one.

The total number of sheets printed during the year has been sixty-five thousand eight hundred and ninety-seven, (65,897.) Of this number, there have been issued from the office fifty-three thousand seven hundred copies, (53,700,) of which thirty-six thousand six hundred and ninety-seven (36,697) have been hydrographic charts, distributed as follows:

To the navy	23,159
To sea captains and pilots employed in government service	2,788
To military officers	2,424
By sale	4,598
Miscellaneous	4,728
Total	36,697

Exclusive of these, upward of seventeen thousand sheets of military maps have been issued from the office by *Mr. V. E. King.*

Of the charts intended for the use of the navy, 19,720 have been distributed through the Naval Observatory.

Those classed under the head "miscellaneous" include those sent to the Light-house Board and persons in their service. A large number have been called for by quartermasters and various revenue officers, and the selected presentations to various foreign vessels-of-war have been many more than usual. Under this head are also included the charts sent to the assistants of the Coast Survey engaged in the various naval expeditions fitted out during the year; also those called for by members of Congress.

The map-room is now much resorted to by the masters of vessels chartered by the government, as also by masters of private vessels, to obtain information as to harbors and parts of the coast they expect to visit. They bear a willing testimony to the accuracy of the charts, and their consequent reliance on them is great, which is shown by the annual increasing sale of those charts.

The distribution of the reports of the superintendent has been small, which is accounted for by the circumstance that last year copies of all the reports then on hand were supplied to the various public libraries, universities, colleges, and other public institutions and associations in the loyal States, while the printed copies of the report of 1862 were not received in time to be included in the present return, except to a very small extent. These reports are coming into considerable demand by masters of vessels, who appear to prize them much. The copies of those years of which there is a considerable number on hand have been freely distributed among this class of men, who, as a class, are more than usually intelligent.

There remains on hand an aggregate number of 14,165 copies of the reports of all years. The stock of some of the early reports, as was observed last year, is now nearly exhausted. The following is a statement of the distribution of these reports during the year:

Distribution made during the year of reports of the United States Coast Survey for the years 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, 1860, 1861, *and* 1862.

Names of States, &c.	Report of 1851.		Report of 1852.		Report of 1853.		Report of 1854.		Report of 1855.		Report of 1856.		Report of 1857.		Report of 1858.		Report of 1859.		Report of 1860.		Report of 1861.		Report of 1862.		Total number distributed.
	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	
Maine					1	1					1	1			2		2	1	41	1	24	2	1		78
New Hampshire					1		1												13		12				27
Massachusetts					3						2				1		7		44		35		1		93
Rhode Island																			3		1				4
Connecticut					1						2				1		3		12		19				39
New York			2		2	1	2		2		4	1	1		1		3		28	2	49	2	3		103
New Jersey	1		1								1		1		3		2		6	1	11	1			28
Pennsylvania							1		1		3		1		3		5		19		42		8		83
Delaware																			2						2
Maryland	1		2		2		1		3		4		3		2		2		3		9				32
District of Columbia	2		4		6		3		2		3		4		2		6		21		45		5		103
South Carolina																							1		1
Louisiana																			1		1		1		3
Ohio															60		61		62		74				257
Kentucky																					1				1
Tennessee											1						1								2
Indiana					1						1		2		2		6		6		10				28
Illinois																	1		1		5				7
Michigan																			1		2				3
Iowa															2		2		1		4				9
Minnesota															1		1		1		1				4
California																					1				1
Oregon																					1				1
Members of Congress			3		9		3				10		1		4		10		10		15				65
Officers of the navy															1		4		2		5		1		13
Officers of the army					1				1		2				2		1		3		4		2		16
Executive departments			1		2		1		1		1		2		2		1		2		9				22
Coast Survey Office assistants	1		1		12		2		2		3		2		3		2		12		31		86		157
Foreign	3		3		3		3		3		3		5		5		7		7		315		14		371
Total	8	....	17	....	44	2	17	....	16	....	41	2	22	....	97	....	127	1	301	4	726	5	123	....	1,553

Folding-room.—The work of backing with muslin the sheets intended for use by the plane-table and hydrographic parties has been performed by *Mr. G. W. Francis.* He has also backed with paper the sailing charts intended for distribution from the office for the use of the navy.

Instrument shop.—The charge of the shop has remained with *Mr. T. J. Hunt,* who is assisted by one workman and three apprentices—the least force that has for years past carried on the necessary operations. As a consequence, the work has been almost exclusively confined to the repairing of instruments used in the field. The finished work of the year consists of six metre scales, six 7-inch German-silver protractors, one prismatic compass, three stands for theodolites, and one pair of magnets. The repair of instruments during the year consists, in part, of twenty-seven theodolites, twenty plane-tables, nine reconnoitring telescopes, six levelling instruments, sixteen sextants, seven prismatic compasses, six marine glasses, four 3-arm protractors, six heliotropes, four surveyors' compasses, twelve metre chains, two hair frames, one astronomical eye-piece, two pantographs, one large astronomical telescope, one tide-gauge, one camera, one astronomical clock, two telegraphic instruments, and two spring governors; in addition to which a great variety of miscellaneous work has been accomplished for office and field purposes.

Carpenter shop.—*Mr. A. Yeatman* still remains in charge of the shop, and is assisted by one workman. During the year the work has included the construction of a large camera, with stands and rail-tracks; two large first-class map cases for the Navy Department; fifteen map and paper cases for the office; thirty-one cases for instruments, such as theodolites, plane-table, &c.; nine new stands for theodolites, plane-table, &c.; two levelling rods; seven plane-table boards; fourteen drawing-boards; seventeen wooden pans and frames for photographic purposes; twelve frames for electrotype purposes; one stand for a large portfolio; rollers and cornices for twenty-two maps; eighty-four tin cases for holding original sheets of the survey have been printed and numbered; and one hundred and twenty-three rough packing boxes for the transportation of instruments and records. In addition to the above, the office buildings and wood-work of instruments have been kept in repair.

APPENDIX No. 11.

REPORT OF PROFESSOR BENJAMIN PEIRCE, OF HARVARD, ON COMPUTATIONS FOR LONGITUDE FROM OCCULTATIONS OF THE PLEIADES.

CAMBRIDGE, *December* 5, 1864.

DEAR SIR: I have the honor to report to you the progress of the computations of the occultations of the Pleiades up to the present date. The group of observations from 1838 to 1842 is wholly under my special charge, with the assistance of Mr. Charles S. Peirce. The computations of the equations of condition are all made for the first time, and the duplicate computation is also almost completed. The preliminary examination of these equations show the most extraordinary agreement of all the observations of each occultation made at good observatories and by experienced observers, and fully justifies the expectations of their value. The agreement, with the tables of Hansen, is also such as to confirm the anticipations of the excellence of those tables; but there are some undoubted discrepancies with observation, which seem to indicate recondite sources of error in the tables, which it may require much time and thought to investigate. Thus the occultations of March 19, 1839, clearly demonstrate an error of the tables of about five seconds of arc. It is easy enough to see what this is not: it is not error of semi-diameter, or of parallax, or of elliptic elements, or of the coefficients of the parallactic equation; but what it is is still a mystery.

The last group of the Pleiades occultations has been put into the hands of computers in the office at Washington by Mr. Schott, under my directions, and is rapidly advancing towards completion.

Very respectfully,

BENJAMIN PEIRCE.

A. D. BACHE, LL.D.,
Superintendent United States Coast Survey.

APPENDIX No. 12.

REPORT OF DR. B. A. GOULD ON THE RESULTS OF COMPUTATIONS FOR LONGITUDE BY THE TELEGRAPHIC METHOD.

CAMBRIDGE, *November*, 1864.

DEAR SIR: In presenting my annual report I have the pleasure of stating that all the determinations of longitude made under my directions have now been rediscussed, with the aid of the standard Right Ascensions of the survey, and with the values for instrument alconstants which a long series of years has enabled us to deduce, and which may properly be regarded as the best attainable.

Three more determinations may be definitely adopted, viz:

	m. s.
Seaton—Raleigh	6 32.93
Raleigh—Columbia	9 35.86
Roslyn—Wilmington	2 11.32

And combining these with the result given in my last report—

Wilmington—Columbia	12 21.72

we find:

Seaton—Wilmington	3 47.07

By the aid of this last value, all the longitudes measured telegraphically in the southern States may be referred to the Seaton station, in Washington, which has, from the beginning, been adopted as the zero point of the telegraphic determinations of the Coast Survey. The longitudes of the respective station points west of the Seaton station thus become:

	m. s.
Petersburg, (Roslyn)	1 35.75
Wilmington, North Carolina	3 47.07
Raleigh	6 32.93
Columbia	16 08.79
Macon	26 30.97
Appalachicola	31 57.33
Eufaula	32 33.99
Montgomery	37 12.55
Pensacola	40 50.79
Lower Peach Tree	42 11.32
Mobile	44 11.07
New Orleans	52 18.23

The measurement Seaton—Roslyn, combined with Roslyn—Wilmington, gives a second and independent determination for the longitude of the last-named station, and illustrates the precision attainable by the telegraphic method. But, close as this accordance already is, I propose subjecting the Seaton—Roslyn determination to a new discussion with the more accurate data now at our disposal before investigating the degree of accordance and the sources of discrepancy. This measurement, and that of Charleston from Raleigh, which is now essentially computed, and needs only the labor of a few weeks for the attainment of a definite result, complete the series of telegraphic determinations, for which adequate materials exist.

A new determination of the difference of longitude between the station points at Washington and New York appears to me highly desirable, and I would urge its importance upon your attention. The obstacles which the war has interposed for the last three years promise soon to be removed, and there may be risk in long delaying this much-needed measurement. Our best value at present depends on the determinations Washington—Philadelphia and Philadelphia—Jersey City, combined with a geodetic reference of the station point in Jersey City to that in New York; and as these were among the earliest telegraphic determinations ever made by present methods, many of the precautions and refinements now in use were naturally omitted.

The experience of another year has seemed to justify the reliance which we have placed upon the accuracy of our standard Right Ascensions. I have known of no reference to them in other terms than commendation from any quarter, with a single exception, to which I will presently refer. The corresponding declinations are still, as described in my last report, in the form of equations of condition, which can readily be solved at any time; but, except in a couple of special cases, the solutions have not been executed, owing to my desire to improve the numerical values for some of the systematic differences, (adopted for reference of the places given to the equinoctial points of Argelander's Positiones Mediæ,) and also to the wish that as many recent determinations may be incorporated as possible.

A very considerable amount of labor has been expended upon the first-named object during the year, especially as bearing upon the declinations of southern stars, and I have been gratified by finding it possible to obtain very satisfactory formulæ for the differences between the catalogue places of the St. Helena and Cape of Good Hope observations and those of Pond and Argelander. Before the expiration of another year I hope to deduce the final results of this discussion of the declinations, and also to subject the list of Right Ascensions to a new scrutiny by means of observations accumulated since the last computation.

The exceptional instance to which I alluded is an astronomer of the Cambridge observatory, who has sharply criticised the values obtained for two of the stars—51 (Hev.) Cephei and Polaris—in two communications, published in the proceedings of the American Academy, of Boston, and reissued in pamphlet form from the observatory. It will be remembered that in the entire list of 176 stars the four polars were the only ones which were not subjected to a new discussion in 1861; but that the positions for these were taken from the investigations made in 1855–'6, and published in volume VI of the Astronomical Journal. The stars whose places, or rather the determination of whose places, have now been criticised and called in question are two of these polars, for which I was prepared to find some discordance manifested after the lapse of nine years from the latest observations employed; but after such examination as I have yet been able to give, I have the pleasure of reporting that my reliance on the results previously deduced has been much strengthened. Moreover, as the error ascribed to the resultant places of the Coast Survey list is not of an order of magnitude recognizable by any transit instrument existing, I have felt warranted in leaving these criticisms unanswered.

Additional investigations have been made during the year concerning the diurnal motions of astronomical instruments in azimuth. The results have been confirmatory of the inferences reported two years ago as to the existence and approximate regularity of the azimuthal fluctuations. I cannot but believe that in all observations, however firm and deep the foundations, and however well mounted the instruments may be, this diurnal oscillation must be brought into account, if the best attainable Right Ascensions are desired.

A value for the azimuth correction deduced from observations made early in the evening will rarely be found applicable to observations later in the night, and *vice versa*.

During the year I have been aided by Messrs. Cleveland Abbe and William H. Palmer, to whom my best acknowledgments are due for valuable and constant assistance. Mr. Abbe, who had given efficient and essential aid for four years, was compelled by ill health to leave my party at the end of July, and the recent resignation of Mr. Palmer from the Coast Survey to enter the naval service leaves a vacancy which will not easily be filled.

I am, very respectfully and truly, your obedient servant,

B. A. GOULD.

Professor A. D. BACHE,

Superintendent United States Coast Survey.

APPENDIX No. 13.

THE PROBLEM OF DETERMINING A POSITION BY ANGLES OBSERVED UPON A NUMBER OF GIVEN STATIONS. SOLUTION OF GAUSS, WITH EXAMPLE, COMMUNICATED BY CHARLES A. SCHOTT, ASSISTANT COAST SURVEY.

The problem of determining a position by angles observed upon three given stations being commonly known as the *three-point problem*, the more general form of the same, where the angles, measured at the sought station between any number of given points, fix its position, may be designated as the *n–point problem*.

According to Gerling,* the solution of this problem was communicated to him by Gauss in 1810; it is given in a somewhat different shape in the Astronomische Nachrichten;† there is also a solution by Bessel.‡

* Pothenotsche Aufgabe, in practischer Beziehung, von C. L. Gerling, Marburg, 1840.

† Anwendung der Wahrscheinlichkeitsrechnung auf eine Aufgabe der practischen Geometrie, vol. i, p. 84.

‡ Zach's Monatliche Correspondenz, 1813, vol. xxvii, p. 222.

The method given below is prepared (a free translation) from Gerling's small work entitled "Pothenot's Problem," or three-point problem, as it is usually called. The practical treatment of this useful problem is given in most standard works on geodesy; this is not the case, however, with the problem when more than three points are given and horizontal angles are measured between them at a station, the position of which is to be determined from these measures. It obviously involves the indirect treatment by the method of least squares; the solution is given here for convenience of reference.

Let

$P_1\ P_2\ P_3 \ldots$ the given points in the order of their azimuths as they appear from the unknown point P.

$\left.\begin{matrix} x_1\ x_2\ x_3 \ldots \\ y_1\ y_2\ y_3 \ldots \end{matrix}\right\}$ their rectangular co-ordinates, those of P being X and Y.

$r_1\ r_2\ r_3 \ldots$ the distances of P from the points $P_1\ P_2\ P_3 \ldots$

$a_1\ a_2\ a_3 \ldots$ the angles which these directions make with the axis of x, which axis of co-ordinates is arbitrary.

$o_1\ o_2\ o_3 \ldots$ the observed angles at P, counted from the initial direction, PP_1.

$$\text{Hence,} \qquad a_2-a_1=o_2,\ a_3-a_1=o_3,\ \text{etc.},$$

and supposing x and y approximate values of X and Y, we have, $x+dx=X$, $y+dy=Y$, $x_1-x=r_1 \cos a_1$, $x_2-x=r_2 \cos a_2$, $x_3-x=r_3 \cos a_3$, etc., $y_1-y=r_1 \sin a_1$, $y_2-y=r_2 \sin a_2$, $y_3-y=r_3 \sin a_3$, etc. We have to express the corrections $da_1, da_2, da_3 \ldots$, to the computed angles $a_1, a_2, a_3 \ldots$, in terms of dx and dy, which corrections should be small, but the process may be repeated if their values should be found too great. Differentiating the expression $tg\, a_1=\frac{y_1-y}{x_1-x}$, we have, $da_1=\left(-\frac{dy}{x_1-x}+(y_1-y)\frac{dx}{(x_1-x)^2}\right) \cos a_1^2$;

$$\text{or,} \qquad da_1=\frac{\sin a_1}{r_1}dx-\frac{\cos a_1}{r_1}dy,$$

$$da_2=\frac{\sin a_2}{r_2}dx-\frac{\cos a_2}{r_2}dy, \text{ etc.}$$

If we wish to express da in seconds, we multiply the right-hand term by radius reduced to seconds, (206264.8.) The approximate values x and y can either be obtained by careful plotting, for which purpose the observed angles at P are drawn upon a piece of transparent paper, which is shifted on the projection until every direction intersects its corresponding point, the position of P may then be marked and the co-ordinates measured;* or, any three points may be selected, (picking out those giving the best conditions,) and x and y found by computation, according to the ordinary formulæ of the three-point problem.

The coefficients of dx and dy can be found either by direct computation from the above expressions, or by the use of the logarithmic differences.

With the assumed values for the position of P, we therefore compute the above co-efficients and compare the computed and observed angles, the differences will form the absolute terms of our conditional equations. The two normal equations are next established and solved, and the resulting values of dx and dy applied to x and y.

If desirable we may also compute the individual errors of the observations.

To illustrate the method, I select an example from my geodetic survey, executed in and near the District of Columbia for military purposes in the winter and spring of 1863, where this kind of survey was frequently employed as both cheap and expeditious; no special signals were erected. The chief purpose was to measure a series of heights by means of measures of zenith distance, the horizontal distances required therefore only to be approximately known. Should the angles measured at the station P contain conditions, such as result from sum-angles or from closing the horizon, we suppose them adjusted by least squares† before entering on the present problem.

Given the following rectangular co-ordinates of six known stations, and the observed angles at the station which is to be determined relatively to them.‡

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* For our in-shore hydrographic survey the three-point problem is almost exclusively used, the angles at the end of each sounding line are measured by a sextant, and the plotting is done mechanically by means of a three-armed brass protractor or tracing paper.

† See on this subject Coast Survey Report of 1854, pp. 70*—79*.

‡ One of the co-ordinates of an outside point, and the approximately measured angle to that point, I have changed to admit of its introduction here, merely for the sake of a more complete example.

m.	m.	° ′ ″
$x_1 = +1845.0.$	$y_1 = +5534.0.$	$o_2 = 61\ 12\ 10$
$x_2 = +1485.0.$	$y_2 = +2486.7.$	$o_3 = 97\ 48\ 27$
$x_3 = 0.0.$	$y_3 = 0.0.$	$o_4 = 195\ 55\ 56$
$x_4 = +4418.2.$	$y_4 = +1416.7.$	$o_5 = 205\ 35\ 04$
$x_5 = +6163.8.$	$y_5 = +398.1.$	$o_6 = 215\ 53\ 44$
$x_6 = +5810.6.$	$y_6 = +1255.7.$	

For an approximate position of P we found from the graphical process, $x = +3448$ metres, and $y = +2440$ metres, and in order to illustrate the numerical process by logarithmic differences, we will select three of the above points, and compute dx and dy to obtain a closer value for x and y for our final solution. With the points P_1 P_3 P_6, we compute as follows:

	log's.
$y_1 - y = +3094.0 - dy.$	$3.49052 \quad -14.0dy.$
$x_1 - x = -1603.0 - dx.$	$3.20493_n + 27.1dx.$
$a_1 = 117°\ 23'\ 19'' + 52.5dx + 27.1dy.$	$0.28559_n - 27.1dx - 14.0dy.$
$y_3 - y = -2440.0 - dy.$	$3.38739_n + 17.8dy.$
$x_3 - x = -3448.0 - dx.$	$3.53757_n + 12.6dx.$
$a_3 = 215°\ 17'\ 07'' - 28.2dx + 40.0dy.$	$9.84982 \quad -12.6dx + 17.8dy.$
$y_6 - y = -1184.3 - dy.$	$3.07346_n + 36.7dy.$
$x_6 - x = +2362.6 - dx.$	$3.37339 \quad -18.4dx.$
$a_6 = 333°\ 22'\ 37'' - 35.0dx - 69.9dy.$	$9.70007_n + 18.4dx + 36.7dy.$

Subtracting a_1 from a_3 and a_6, we find,

$$o_3 = 97°\ 53'\ 48'' - 80.7dx + 12.9dy,$$
$$o_6 = 215\ 59\ 18 - 87.5dx - 97.0dy,$$

and by comparing with the observed values,

$$0 = +321 - 80.7dx + 12.9dy,$$
$$0 = +334 - 87.5dx - 97.0dy,$$

hence, $dx = +4.^{m}0$, $dy = -0.^{m}1$, and $x + dx = 3452.^{m}0$, $y + dy = +2439.^{m}9$.

If we now compute the differential equations, using for x and y the above improved values, or 3452 and 2440, the final solution stands as follows:

	1.	2	3.	4.	5.	6.
$y_n - y$	+ 3094.0	+ 46.7	— 2440.0	— 1023.3	— 2041.9	— 1184.3
$x_n - x$	— 1607.0	— 1967.0	— 3452.0	+ 966.2	+ 2711.8	+ 2358.6
$\lg (y_n - y)$	3.4905203 +	1.6693169 +	3.3873898 —	3.0100030 —	3.3100345 —	3.0734117 —
$\lg (x_n - x)$	3.2060159 —	3.2938044 —	3.5380708 —	2.9850670 +	3.4332577 +	3.3726543 +
$\lg \operatorname{tg} a_n$	0.2845044 —	8.3755125 —	9.8493190 +	0.0249360 —	9.8767768 —	9.7008074 —
a_n	117° 26′ 49″	178° 38′ 24″	215° 15′ 15″	313° 21′ 22″	323° 01′ 17″	333° 20′ 16″
$\lg \sin a_n$	9.94814 +	8.37538 +	9.76133 —	9.86159 —	9.77925 —	9.65199 —
$\lg \cos a_n$	9.66363 —	9.99988 —	9.91201 —	9.83666 +	9.90247 +	9.95118 +
$\lg r_n$	3.54239	3.29392	3.62606	3.14841	3.53079	3.42147
$\lg \left(\frac{\sin a_n}{r_n}\right)''$	1.72018 +	0.39589 +	1.44970 —	2.02761 —	1.56289 —	1.54495 —
$\lg \left(\frac{\cos a_n}{r_n}\right)''$	1.43567 —	2.02039 —	1.60038 —	2.00268 +	1.68611 +	1.84414 +
$\frac{\sin a_n}{r_n}$	+ 52.50	+ 2.49	— 28.16	— 106.56	— 36.55	— 35.07
$-\frac{\cos a_n}{r_n}$	+ 27.27	+ 104.81	+ 39.85	— 100.62	— 48.54	— 69.85
Subtracting a_1		61 11 35	97 48 26	195 54 33	205 34 28	215 53 27
Subtracting $\frac{\sin a_1}{r_1}$		— 50.01	— 80.66	— 159.06	— 89.05	— 87.57
Subtracting $-\frac{\cos a_1}{r_1}$		+ 77.54	+ 12.58	— 127.89	— 75.81	— 97.12

By comparison with the observed angles we obtain the conditional equations:

$$0=-35-\ 50.01dx+\ 77.54dy,$$
$$0=-\ 1-\ 80.66dx+\ 12.58dy,$$
$$0=-83-159.06dx-127.89dy,$$
$$0=-36-\ 89.05dx-\ 75.81dy,$$
$$0=-17-\ 87.57dx-\ 97.11dy.$$

Normal equations:

$$0=+19728+49906dx+30704dy,$$
$$0=+12268+30704dx+37705dy.$$
$$dx=-0.39,\ dy=-0.01,\text{ and } X=+3451.^{m}61,\ Y=+2439.^{m}99.$$

If the measured angles are of unequal accuracy, weights are to be introduced before the formation of the normal equations. If we introduce the values of dx and dy in the expressions of $d\alpha_n$, and apply the resulting corrections to the computed α_n, we find, by subtracting α_1 from all the rest, the final corrected angles, which we can compare with the observed angles $o_2, o_3, o_4 \ldots$, when we obtain the residuals, (obs'd—comp'd,)

$$v_2=+16.''0,$$
$$v_3=-30.4,$$
$$v_4=+20.0,$$
$$v_5=+\ 0.9,$$
$$v_6=-17.9,$$

hence the apparent probable error of any one angle $\varepsilon=\sqrt{\frac{0.455+1901}{5-2}}=\pm 17.''0$. The above residuals are in part (the smaller) due to the incidental errors of the observed angles, and in part to inherent errors in the adopted co-ordinates of the known points, which produce for short distances apparently large differences in the angles.

To obtain the uncertainty in the co-ordinates themselves, we form the two sets of weight equations and deduce,

$$\varepsilon_x=\pm 0.^{m}11,\text{ and } \varepsilon_y=\pm 0.^{m}12.$$

If all the points fall either in the circumference of a circle or in a straight line, the problem becomes indeterminate; but even an approach to this condition will rarely occur, and is less likely to happen the greater the number of given points above three.

A convenient direct solution of the three-point problem is here presented under a very concise form:

We number the given points in the order of their azimuths, as seen from the fourth point P, which is to be determined, and distinguish three cases, viz: the middle point, P_2, is on the same side of the line, joining P_1 and P_3, as is P; or, secondly, P_2 is on the opposite side; or, thirdly, P is inside the triangle P_1, P_2, P_3. It is only in the second case that we need look for an approach to, or for the limitation of, the problem.

Let $\left.\begin{array}{l} P_1\,P\,P_2=\alpha \\ P_2\,P\,P_3=\beta \end{array}\right\}$ the measured angles;

$P_1\,P_2\,P_3=\gamma,$

also, $P_2\,P_1\,P=x,$

$P\,P_3\,P_2=y,$ put $tg\ \varphi=\frac{P_1\,P_2}{P_2\,P_3}\cdot\frac{\sin\beta}{\sin\alpha}=\frac{\sin y}{\sin x},$

then for the first case, $x+y=-\alpha-\beta+\gamma$, for the second and third put $360-\gamma$ for γ, and $tg\tfrac{1}{2}(x-y)=\frac{tg\frac{1}{2}(x+y)}{tg(\varphi+45^\circ)}$.

For verification, $P\,P_2=P_1\,P_2\frac{\sin x}{\sin\alpha}=P_2\,P_3\frac{\sin y}{\sin\beta}$.

APPENDIX No. 14.

REPORT ON THE METHOD OF REDUCTION, AND RESULTS OF THE CONNEXION OF THE EPPING BASE LINE WITH THE PRIMARY TRIANGULATION IN THE EASTERN STATES. BY CHARLES A. SCHOTT, ASSISTANT UNITED STATES COAST SURVEY.

COAST SURVEY OFFICE, *June* 7, 1864.

(1.) *General remarks on the method of reduction.*

The geodetic connexion of the Epping base with the primary triangulation forms the first step in the computation of the great triangulation connecting the Epping and Fire Island base lines with its branch reaching to the Massachusetts base. The application of the method of least squares, without which the reduction could not be satisfactorily accomplished, necessitates, from the complexity of the numerical operations, that the series of triangles should be divided into parts so as to bring each within a limit of practical solution. The number of subdivisions thus practically demanded must be very few, and they should be specially selected to detract as little as possible from the theoretical rigor required by the method. Thus we are obliged to adjust by the method of least squares the angles measured at each station separately, as their introduction in the general geometric condition of the triangulation would swell the conditional equations to hundreds, and indeed there may be a question whether the adjustment of the measures at each station is not the preferable method, reserving a further adjustment to the geometrical requirements of the triangles. Again, the connexion of the Epping base alone with the primary sides of the triangulation, which forms the subject of this report, is so complete as to require the establishment and solution of thirty-five equations, which number would be increased to such an extent, if we were directly to connect one base with the next, as to become perfectly unwieldy. The connexion of the Epping base with the primary side Humpback—Mount Desert may be regarded as a distinct operation, which receives further interest from the fact that it requires a combination of results from measures of angles (by repeating theodolite) and from measures of directions, (direct observations by the thirty-inch theodolite,) also an improved application of weights, and, in general, it may serve, as a specimen, to illustrate the subsequent reduction of the main triangulation of the survey in this section of the country.

(2.) *Instruments and methods of horizontal measures employed in the triangulation near the Epping base.*

The horizontal angles at the base, and at three stations next following, were measured with a repeating theodolite (Coast Survey, No. 43,) by the party in charge of Assistant C. O. Boutelle; those at the remaining four stations were determined by measures of direction with the thirty-inch theodolite (Coast Survey, No. 1.) by the party in charge of Professor A. D. Bache, Superintendent. The first-named instrument is a ten-inch Gambey, read by means of verniers; the second is provided and read with microscopes. The reduction of the angles from observed directions has been sufficiently explained in Coast Survey Report of 1854, pp. 71* o 76*, and for the case when angles were measured by repetition or combination in the same Report, pp. 76* to 79*. The determination of the probable error and weight of each result, however, requires further exposition. It should also be stated that Peirce's criterion has been applied to the reduction of the observations.

(3.) *Determination of probable error and weight to each direction observed with the thirty-inch theodolite.*

The method of obtaining the *average* probable error and weight of directions measured with the thirty-inch theodolite at any one station has been explained and illustrated in Coast Survey Report of 1854, pp. 86* to 90*, and the small modification required to render the method applicable to *each* direction will appear sufficiently plain from the following example for Station Howard.

To carry out the determination of probable errors in all the theoretical strictness is far too laborious for actual use, and in fact is not required, as a close approximation fully suffices.

We form first the abstract of remaining differences, referred to the initial direction of each series; this abstract is obtained from the abstract of diminished measures by applying the corrections A, B, C, D, etc., with their signs changed to the respective quantities in the abstract of diminished measures; for another initial direction than the first, the proper differences (corrections with reversed sign) are to be applied. Frequently the corrections to the assumed angles are small, less than 0.″1; in such cases no correction was required. In forming the abstract all directions are included, whether belonging to the primary series or not; the hundredths of seconds have been dropped. The last column contains the average difference in each series.

STATION HOWARD.

Abstract of remaining differences.

Pigeon.	Mt. Desert.	Burke.	East Base.	Humpback.	Mitten.	Cooper.	Azimuth mark.	Trescott Rock.	Grand Menan.	Seal Island Light.	Mean.
"	"	"	"	"	"	"	"	"	"	"	"
0.0	0.1	1.7	1.0	3.1	1.8	1.8	1.6	2.4	7.5	0.1	1.9
0.0	1.7	59.7	1.4	2.4	3.7	1.9	1.8	3.3	3.7	2.7	2.0
0.0	4.8	1.1	57.6	1.8	4.5	3.9	0.8	1.3	2.0	59.3	1.5
0.0	1.9	58.7	0.7	59.4	2.4	2.4	1.2	0.2	0.7	59.9	0.7
0.0	57.9	1.8	0.9	57.6	57.8	55.8	55.9	58.0	55.9	59.3	58.3
0.0	0.1	0.0	58.5	55.2	55.0	54.1	54.5	57.5	56.7	56.4	57.1
0.0	53.7	0.4	3.5	56.5	58.9	58.9	59.0	0.2	59.8	1.2	59.3
0.0	2.1	0.3	59.0	58.6	0.5	59.4	58.9	3.1	1.8	0.0	0.3
0.0	58.6	2.5	3.5	0.9	1.0	0.8	1.3	1.4	58.9	58.1	0.6
0.0	59.8	59.9	0.4	2.8	59.5	1.2	59.7	1.3	57.2	58.7	0.0
0.0	59.5	59.4	0.6	4.0	0.1	59.7	1.6	1.3	3.0	1.1	0.9
0.0	5.0	1.7	3.0	4.2	1.8	4.0	3.7	2.1	1.8	59.8	2.5
0.0	0.7	59.4	58.8	1.0	1.9	59.6	58.7	57.9	59.2	2.2	59.9
0.0	3.3	4.6	1.0	55.8	56.9	59.2	1.9	59.3	58.9	2.2	0.3
0.0	58.1	4.1	4.8	53.5	55.5	56.9	57.2	54.3	55.9	58.0	58.0
0.0	59.8	0.2	3.3	1.8	1.0	57.3	58.3	59.5	56.6	59.9	59.8
0.0	2.2	2.3	1.1	4.7	2.3	2.3	3.7	4.3	2.6	1.9	2.5
0.0	0.3	0.6	0.5	3.1	2.4	3.6	1.5	1.0	0.0	59.2	1.1
0.0	2.4	59.4	0.7	2.0	2.8	2.7	3.7	4.0	2.2	3.1	2.1
0.0	57.4	58.6	59.8	0.6	0.4	1.7	2.4	0.9	0.4	0.4	0.2
0.0	0.5	56.5	59.3	2.0	59.6	0.5	3.8	59.3	59.8	1.1	0.2
0.0	0.1	57.6	59.9	59.5	59.7	0.5	59.6	59.7	59.8	59.5	59.6
0.0	0.0	59.2	59.4	3.6	2.9	0.5	1.9	0.6	2.4	....	1.0
0.0	0.2	2.6	59.4	2.7	0.4	0.6	0.4	1.3	59.9	....	0.7
0.0	1.0	0.4	58.1	0.2	2.1	1.2	0.9	59.5	0.3	....	0.4
0.0	59.1	58.9	57.0	55.9	54.0	58.2	56.8	54.9	57.6	....	57.2
0.0	59.0	59.4	56.2	55.6	56.9	57.0	56.8	0.5	57.0	....	57.8
0.0	59.2	58.9	2.7	0.3	3.8	0.7	2.4	1.3	0.4	....	1.0
0.0	58.9	0.7	58.5	59.7	1.8	59.6	0.6	1.7	1.5	....	0.3
0.0	3.3	0.4	57.6	4.0	2.6	3.7	2.2	0.0	3.7	....	1.7
0.0	58.5	58.0	56.8	58.8	1.3	58.6	59.5	55.7	0.0	....	58.7
0.0	59.9	59.7	1.7	1.9	1.1	1.2	1.1	58.8	0.3	....	0.6
0.0	59.3	58.9	59.4	3.2	59.8	59.3	0.1	4.0	....	6.8	1.1
0.0	0.9	57.5	58.2	0.2	59.4	0.3	59.3	58.3	....	58.9	59.3
0.0	58.5	....	57.0	57.0	58.7	58.6	58.1	0.0	57.3	58.3	58.3
0.0	58.5	58.3	58.8	59.3	1.2	59.7	58.9	....	58.2	....	59.2
0.0	59.3	0.0	59.5	1.5	0.9	58.9	59.5	....	57.8	....	59.7
0.0	59.8	56.1	58.9	0.6	2.4	0.8	0.9	....	1.4	....	0.1
0.0	....	56.7	1.3	58.9	55.2	58.0	57.5	54.2	....	59.9	58.0
0.0	....	2.7	0.1	57.0	0.2	59.2	59.9	....	59.5	....	59.8
0.0	57.9	0.9	57.8	2.5	1.3	1.4	58.4	....	....	....	0.0
0.0	....	0.5	59.8	0.2	....	59.2	57.9	....	1.7	....	59.9
0.0	....	59.3	56.1	58.3	....	57.9	59.3	....	0.1	....	58.7
0.0	....	54.7	58.3	56.9	....	58.3	58.3	....	56.9	....	57.7
0.0	....	....	0.1	58.8	57.9	58.4	58.7	....	58.4	....	58.9
0.0	58.7	1.5	59.6	53.6	54.2	57.1	....	....	....	....	57.8
0.0	0.7	3.1	2.8	4.1	....	3.0	3.4	....	....	....	2.5
0.0	....	....	1.9	0.3	....	1.2	0.2	....	58.4	....	0.3
0.0	....	....	56.6	58.5	....	0.5	59.5	....	58.1	....	58.9
0.0	....	....	59.1	1.9	....	1.2	0.0	....	1.0	....	0.5
....	0.0	2.8	59.0	55.8	54.6	56.4	....	....	....	....	58.1
....	0.0	58.6	1.3	56.4	57.2	56.7	....	....	....	....	58.4
....	....	....	0.0	56.3	56.2	57.6	57.6	....	59.1	....	57.8
....	0.0	57.9	0.2	57.5	....	56.6	....	....	....	....	58.4
....	0.0	0.1	1.5	59.3	....	59.9	....	....	....	....	0.2
....	0.0	1.2	1.4	1.6	....	3.0	....	....	....	....	1.4
....	....	....	....	....	....	0.0	58.8	....	59.7	....	59.5
....	....	....	....	....	....	....	0.0	1.1	....	59.1	0.1

The abstract of remaining errors is formed by comparing each difference of the preceding abstract with the mean of its series; it contains, therefore, for each measure the difference from the mean; let this difference be Δ, we then form Δ^2 and $\Sigma\Delta^2$ for each direction. If s equal the number of observations of any one direction, the formula $\varepsilon_1^2=\frac{0.455\Sigma\Delta^2}{s(s-1)}$ gives an approximation to the square of the probable error of a direction; to give, however, proper weight to the results, since the Δ's of the more full series are more correct than of series with less directions, it is preferable to substitute for $s-1$ the diagonal coefficient of the weight equations, (omitting the remaining combinations;) this gives for the probable error of the first direction,

$$\varepsilon_1=\sqrt{\frac{0.455\Sigma\Delta^2}{s[xx]}};$$

for the second direction, $\varepsilon_1=\sqrt{\frac{0.455\Sigma\Delta^2}{s[aa]}}$;

for the third direction, $\varepsilon_1=\sqrt{\frac{0.455\Sigma\Delta^2}{s[bb]}}$, &c.;

we also have, weight, $w=\frac{1}{\varepsilon_1^2}$.

The labor of squaring is not great in the present case, otherwise the formula, Coast Survey Report of 1856, p. 307, might be employed.

Abstract of remaining errors.

Pigeon.		Mt. Desert.		Burke.		East Base.		Humpback.		Mitten.		Cooper.		Az. mark.		Trescott.		Gr. Men.		Seal I. Lt.	
Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2	Δ	Δ^2
1.9	3.6	1.8	3.2	0.2	0.0	0.9	0.8	1.2	1.4	0.1	0.0	0.1	0.0	0.3	0.1	0.5	0.2	5.6	31.4	1.8	3.2
2.0	4.0	0.3	0.1	2.3	5.3	0.6	0.4	0.4	0.2	1.7	2.9	0.1	0.0	0.2	0.0	1.3	1.7	1.7	2.9	0.7	0.5
1.5	2.2	3.3	10.9	0.4	0.2	3.9	15.2	0.3	0.1	3.0	9.0	2.4	5.8	0.7	0.5	0.2	0.0	0.5	0.2	2.2	4.8
0.7	0.5	1.2	1.4	2.0	4.0	0.0	0.0	1.3	1.7	1.7	2.9	1.7	2.9	0.5	0.2	0.5	0.2	0.0	0.0	0.8	0.6
1.7	2.9	0.4	0.2	3.5	12.2	2.6	6.8	0.7	0.5	0.5	0.2	2.5	6.2	2.4	5.8	0.3	0.1	2.4	5.8	1.0	1.0
2.9	8.4	3.0	9.0	2.9	8.4	1.4	2.0	1.9	3.6	2.1	4.4	3.0	9.0	2.6	6.8	0.4	0.2	0.4	0.2	0.7	0.5
0.7	0.5	5.6	31.4	1.1	1.2	4.2	17.6	2.8	7.8	0.4	0.2	0.4	0.2	0.3	0.1	0.9	0.8	0.5	0.2	1.9	3.6
0.3	0.1	1.8	3.2	0.0	0.0	1.3	1.7	1.7	2.9	0.2	0.0	0.9	0.8	1.4	2.0	2.8	7.8	1.5	2.2	0.3	0.1
0.6	0.4	2.0	4.0	1.9	3.6	2.9	8.4	0.3	0.1	0.4	0.2	0.2	0.0	0.7	0.5	0.8	0.6	1.7	2.9	2.5	6.2
0.0	0.0	0.2	0.0	0.1	0.0	0.4	0.2	2.8	7.8	0.5	0.2	1.2	1.4	0.3	0.1	1.3	1.7	2.8	7.8	1.3	1.7
0.9	0.8	1.4	2.0	1.5	2.2	0.3	0.1	3.1	9.6	0.8	0.6	1.2	1.4	0.7	0.5	0.4	0.2	2.1	4.4	0.2	0.0
2.5	6.2	2.5	6.2	0.8	0.6	0.5	0.2	1.7	2.9	0.7	0.5	1.5	2.2	1.2	1.4	0.4	0.2	0.7	0.5	2.7	7.3
0.1	0.0	0.8	0.6	0.5	0.2	1.1	1.2	1.1	1.2	2.0	4.0	0.3	0.1	1.2	1.4	2.0	4.0	0.7	0.5	2.3	5.3
0.3	0.1	3.0	9.0	4.3	18.5	0.7	0.5	4.5	20.2	3.4	11.6	1.1	1.2	1.6	2.6	1.0	1.0	1.4	2.0	1.9	3.6
2.0	4.0	0.1	0.0	6.1	37.2	6.8	46.2	4.5	20.2	2.5	6.2	1.1	1.2	0.8	0.6	3.7	13.7	2.1	4.4	0.0	0.0
0.2	0.0	0.0	0.0	0.4	0.2	3.5	12.2	2.0	4.0	1.2	1.4	2.5	6.2	1.5	2.2	0.3	0.1	3.2	10.2	0.1	0.0
2.5	6.2	0.3	0.1	0.2	0.0	1.4	2.0	2.2	4.8	0.2	0.0	0.2	0.0	1.2	1.4	1.8	3.2	0.1	0.0	0.6	0.4
1.1	1.2	0.8	0.6	0.5	0.2	0.6	0.4	2.0	4.0	1.3	1.7	2.5	6.2	0.4	0.2	0.1	0.0	1.1	1.2	1.9	3.6
2.1	4.4	0.3	0.1	2.7	7.3	1.4	2.0	0.1	0.0	0.7	0.5	0.6	0.4	1.6	2.6	1.9	3.6	0.1	0.0	1.0	1.0
0.2	0.0	2.8	7.8	1.6	2.6	0.4	0.2	0.4	0.2	0.2	0.0	1.5	2.2	2.2	4.8	0.7	0.5	0.2	0.0	0.2	0.0
0.2	0.0	0.3	0.1	3.7	13.7	0.9	0.8	1.8	3.2	0.6	0.4	0.3	0.1	3.6	13.0	0.9	0.8	0.4	0.2	0.9	0.8
0.4	0.2	0.5	0.2	2.0	4.0	0.3	0.1	0.1	0.0	0.1	0.0	0.9	0.8	0.0	0.0	0.1	0.0	0.2	0.0	0.1	0.0
1.0	1.0	1.0	1.0	1.8	3.2	1.6	2.6	2.6	6.8	1.9	3.6	0.5	0.2	0.9	0.8	0.4	0.2	1.4	2.0	......	......
0.7	0.5	0.5	0.2	1.9	3.6	1.3	1.7	2.0	4.0	0.3	0.1	0.1	0.0	0.3	0.1	0.6	0.4	0.8	0.6	......	......
0.4	0.2	0.6	0.4	0.0	0.0	2.3	5.3	0.2	0.0	1.7	2.9	0.8	0.6	0.5	0.2	0.9	0.8	0.1	0.0	......	......
2.8	7.8	1.9	3.6	1.7	2.9	0.2	0.0	1.3	1.7	3.2	10.2	1.0	1.0	0.4	0.2	2.3	5.3	0.4	0.2	......	......
2.2	4.8	1.2	1.4	1.6	2.6	1.6	2.6	2.2	4.8	0.9	0.8	0.8	0.6	1.0	1.0	2.7	7.3	0.8	0.6	......	......
1.0	1.0	1.8	3.2	2.1	4.4	1.7	2.9	0.7	0.5	2.8	7.8	0.3	0.1	1.4	2.0	0.3	0.1	0.6	0.4	......	......
0.3	0.1	1.4	2.0	0.4	0.2	1.8	3.2	0.6	0.4	1.5	2.2	0.7	0.5	0.3	0.1	1.4	2.0	1.2	1.4	......	......
1.7	2.9	1.6	2.6	1.3	1.7	4.1	16.8	2.3	5.3	0.9	0.8	2.0	4.0	0.5	0.2	1.7	2.9	2.0	4.0	......	......
1.3	1.7	0.2	0.0	0.7	0.5	1.9	3.6	0.1	0.0	2.6	6.8	0.1	0.0	6.8	0.6	3.0	9.0	1.3	1.7	......	......
0.6	0.4	0.7	0.5	0.9	0.8	1.1	1.2	1.3	1.7	0.5	0.2	0.6	0.4	0.5	0.2	1.8	3.2	0.3	0.1	......	......
1.1	1.2	1.8	3.2	2.2	4.8	1.7	2.9	2.1	4.4	1.3	1.7	1.8	3.2	1.0	1.0	2.9	8.4	......	......	5.7	32.5
0.7	0.5	1.6	2.6	1.8	3.2	1.1	1.2	0.9	0.8	0.1	0.0	1.0	1.0	0.0	0.0	1.0	1.0	......	......	0.4	0.2
1.7	2.9	0.2	0.0	......	......	1.3	1.7	1.3	1.7	0.4	0.2	0.3	0.1	0.2	0.0	1.7	2.9	1.0	1.0	0.0	0.0
0.8	0.6	0.7	0.5	0.9	0.8	0.4	0.2	0.1	0.0	2.0	4.0	0.5	0.2	0.3	0.1	......	......	1.0	1.0	......	......

Abstract of remaining errors—Continued.

Pigeon.		Mt. Desert.		Burke.		East Base.		Humpback.		Mitten.		Cooper.		Az. mark.		Trescott.		Gr. Men.		Seal I. Lt.	
Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²	Δ	Δ²
0.3	0.1	0.4	0.2	0.3	0.1	0.2	0.0	1.8	3.2	1.2	1.4	0.8	0.6	0.2	0.0	.....	.....	1.9	3.6	.....	.....
0.1	0.0	0.3	0.1	4.0	16.0	1.2	1.4	0.5	0.2	2.3	5.3	0.7	0.5	0.8	0.6	.....	.....	1.3	1.7	.....	.....
2.0	4.0	.....	.....	1.3	1.7	3.3	10.9	0.9	0.8	2.8	7.8	0.0	0.0	0.5	0.2	3.8	14.4	.....	.....	1.9	3.6
0.2	0.0	.....	.....	2.9	8.4	0.3	0.1	2.8	7.8	0.2	0.0	0.6	0.4	0.1	0.0	.....	.....	0.3	0.1	.....	.....
0.0	0.0	2.1	4.4	0.9	0.8	2.2	4.8	2.5	6.2	1.3	1.7	1.4	2.0	1.6	2.6	.....	.....	.....	.....	.....	.....
0.1	0.0	.....	.....	0.6	0.4	0.1	0.0	0.3	0.1	.....	.....	0.7	0.5	2.0	4.0	.....	.....	1.8	3.2	.....	.....
1.3	1.7	.....	.....	0.6	0.4	2.6	6.8	0.4	0.2	.....	.....	0.8	0.6	0.6	0.4	.....	.....	1.4	2.0	.....	.....
2.3	5.3	.....	.....	3.0	9.0	0.6	0.4	0.8	0.6	.....	.....	0.6	0.4	0.6	0.4	.....	.....	0.8	0.6	.....	.....
1.1	1.2	.....	.....	.....	.....	1.2	1.4	0.1	0.0	1.0	1.0	0.5	0.2	0.2	0.0	.....	.....	0.5	0.2	.....	.....
2.2	4.8	0.9	0.8	3.7	13.7	1.8	3.2	4.2	17.6	3.6	13.0	0.7	0.5	.....	.....	.....	.....	.....	.....	.....	.....
2.5	6.2	1.8	3.2	0.6	0.4	0.3	0.1	1.6	2.6	.....	.....	0.5	0.2	0.9	0.8	.....	.....	.....	.....	.....	.....
0.3	0.1	.....	.....	.....	.....	1.6	2.6	0.0	0.0	.....	.....	0.9	0.8	0.1	0.0	.....	.....	1.9	3.6	.....	.....
1.1	1.2	.....	.....	.....	.....	2.3	5.3	0.4	0.2	.....	.....	1.6	2.6	0.6	0.4	.....	.....	0.8	0.6	.....	.....
0.5	0.2	.....	.....	.....	.....	1.4	2.0	1.4	2.0	.....	.....	0.7	0.5	0.5	0.2	.....	.....	0.5	0.2	.....	.....
		1.9	3.6	4.7	22.1	0.9	0.8	2.3	5.3	3.5	12.2	1.7	2.9	.....	.....	.....	.....	.....	.....	.....	.....
		1.6	2.6	0.2	0.0	2.9	8.4	2.0	4.0	0.8	0.6	1.7	2.9	.....	.....	.....	.....	.....	.....	.....	.....
						2.2	4.8	1.5	2.2	1.6	2.6	0.2	0.0	0.2	0.0	.....	.....	1.3	1.7	.....	.....
		1.6	2.6	0.5	0.2	1.8	3.2	6.9	0.8	.....	.....	1.8	3.2	.....	.....	.....	.....	.....	.....	.....	.....
		0.2	0.0	0.1	0.0	1.3	1.7	0.9	0.8	.....	.....	0.3	0.1	.....	.....	.....	.....	.....	.....	.....	.....
		1.4	2.0	0.2	0.0	0.0	0.0	0.2	0.0	.....	.....	1.6	2.6	.....	.....	.....	.....	.....	.....	.....	.....
												0.5	0.2	0.7	0.5	.....	.....	0.2	0.0	.....	.....
												.....	.....	0.1	0.0	1.0	1.0	.....	.....	1.0	1.0

	Pigeon.	Mt. Desert.	Burke.	East Base.	Humpback.	Mitten.	Cooper.	Az. mark.	Trescott.	Gr. Men.	S. I. Lt.
Directions.	Sum of $\triangle^2$										
(11)	45.7	90.1	121.6	119.0	96.4	46.9	48.3	46.8	40.6	77.0	44.2
(10)	25.0	20.7	27.9	45.7	32.1	37.3	11.7	6.4	43.5	12.0	32.7
(9)	4.7	0.8	18.6	12.5	4.2	18.5	1.3	0.9	14.4	6.3	3.6
(8)	0.0	4.4	9.2	4.9	14.0	1.7	2.4	2.6	....	0.1	....
(7)	19.2	4.0	23.9	11.9	21.1	14.0	2.4	5.6	....	6.0	....
(6)	1.5	6.2	22.1	23.9	13.7	15.4	9.7	0.6	....	6.1	....
(5)	....	4.6	0.2	4.9	1.6	....	5.9	....	....	....	....
(3)	....	....	....	....	....	....	0.2	0.5	1.0	0.0	1.0
$\Sigma \triangle^2$......	96.1	130.8	223.5	222.8	183.1	133.8	81.9	63.4	99.5	107.5	81.5
Diag. coef..	44.6	41.0	44.5	49.5	49.5	41.2	50.2	46.0	33.3	40.9	24.3

	Pigeon.	Mt. Desert.	Burke.	East Base.	Hump-back.	Mitten.	Cooper.	Azimuth mark.	Trescott Rock.	Grand Menan.	Seal I'd Light.
s	50	46	50	56	56	46	57	52	37	46	27
lg $\Sigma\Delta^2$	1.983	2.117	2.349	2.348	2.263	2.126	1.913	1.802	1.998	2.031	1.911
lg 0.455 $\Sigma\Delta^2$.........	1.640	1.774	2.007	2.005	1.920	1.784	1.571	1.459	1.655	1.689	1.568
$s[\ \ ]$..............	2230	1886	2225	2772	2772	1895	2861	2392	1232	1881	656
lg $s[\ \ ]$	3.348	3.275	3.347	3.443	3.443	3.278	3.457	3.379	3.091	3.274	2.817
$\lg w = \frac{1}{\varepsilon_1^2}$	1.708	1.501	1.340	1.438	1.523	1.494	1.886	1.919	1.435	1.585	1.248
w	51.1	31.8	21.9	27.4	33.3	31.2	76.9	83.1	27.3	38.5	17.7
lg ε_1^2	8.291	8.498	8.659	8.562	8.477	8.506	8.114	8.080	8.564	8.414	8.751
ε_1^2	0.020	0.032	0.046	0.037	0.030	0.032	0.013	0.012	0.037	0.026	0.056
$\varepsilon_1 = \pm$	0.″140	0.″177	0.″213	0.″191	0.″173	0.″179	0.″114	0.″110	0.″191	0.″161	0.″238

The average value of ε_1 for this station, omitting the secondary directions, Mitten, Trescott Rock, and Seal Island Light, is $\pm 0.''160$.

The probable error ε_1 and weight w to each direction, observed with the thirty-inch theodolite, has been computed as shown above; the results are given with the resulting directions at each station.

(4.) *Determination of probable error and weight to each angle and direction from observations with a repeating circle.*

We find by the usual process of comparison of each observed measure of an angle, (in our case of six repetitions, half of which measured with telescope direct, and half with tel scope reversed,) with its resulting value, the square of the probable error of any such single measure. This was done for each angle in the abstract of results. The quantity divided by two gives the square of the probable error of any such single direction, or e_1^2. Thus at East Base we have the following observed angles of six repetitions, each between stations Burke and Tunk:

	Δ		Δ
° ′ ″	″	° ′ ″	″
25 46 40.8	2.6	25 46 44.5	1.1
41.2	2.2	43.1	0.3
41.7	1.7	47.2	3.8
41.5	1.9	44.5	1.1
40.5	2.9	43.6	0.2
43.4	0.0	45.0	1.6
40.3	3.1	45.9	2.5
45.9	2.5	44.8	1.4
44.4	1.0	42.5	0.9
42.4	1.0	44.0	0.6

Average angle 25° 46′ 43.″36.

$$e_0 = 0.845 \frac{\Sigma \Delta}{\sqrt{n(n-1)}} = \pm 1.''41, \text{ and } e_1^2 = 0.994.$$

As each direction occurs in several combinations of angles, we can find several values of e_1^2; the average value has been taken to represent this quantity. Twenty sets of observations having been made for each angle, we divide the above number by 20, and obtain the square of the probable observing error of a resulting direction, or ε^2.

We next write down the number of times, m, each direction enters in combination with measured angles, (the twenty measures of each angle being now taken as the unit,) and form $\frac{\varepsilon^2}{m}$ for each direction.

Thus for station East Base we have:

	Mt. Desert.	Burke.	Tunk.	West Base.	Humpback.	Howard.	Pigeon.
Values of e_1^2 from 14 angles.	0.744 1.095 1.940 0.884	0.994 1.748 0.650 0.594	0.994 1.080 1.446 0.884	0.320 0.708 0.594	1.095 1.446 0.650 0.871 0.708	1.940 0.871 0.387	1.080 0.744 1.748 0.387 0.320
e_1^2	1.166	0.997	1.101	0.541	0.954	1.066	0.856
ε^2	0.0583	0.0499	0.0550	0.0270	0.0477	0.0533	0.0428
m	4	4	4	3	5	3	5
$\frac{\varepsilon^2}{m}$	0.0146	0.0125	0.0138	0.0090	0.0095	0.0178	0.0086

We have next to find the combination error resulting from the adjustment of the angles at each station. This error must be taken the same for each direction, and is found by subtracting the observing error from the sum of the combination and observing errors; thus we compare the adjusted angles with the observed angles, taking care at the same time to take out any constant quantity by which repeating angles are liable to differ constantly by the same small amount; this will give the square of the observing and combination errors, or ε^2_{0+c} (for any result of twenty measures;) subtracting ε^2 we have the combination error for each direction, $\varepsilon^2_c = \varepsilon^2_{0+c} - \varepsilon^2$.

Example of the computation of ε^2_c for station East Base:

We have here fourteen conditional and six normal equations. Let Δ equal the residual between the adjusted and observed angles, or A−O, the sum of the positive values of Δ is 4.90, and of the negative values, 2.11; hence, $\frac{4.90-2.11}{14}=+0.''20$, the quantity by which on the average the angles around East Base were measured too small. This we subtract from each Δ before squaring, and finally deduce $\varepsilon^2_{0+c}=\frac{0.455\Sigma(\Delta-.''20)^2}{2(14-6)}$.

$\Delta=$	$\Delta-.20=$	$(\Delta-.20)^2=$	
− .30	.50	.25	
+ .42	.22	.05	
+ .60	.40	.16	
+ .71	.51	.26	
− .20	.40	.16	$\varepsilon^2_{0+c}=\frac{0.455\times4.14}{16}$
− .22	.42	.18	$=0.1178$
− .32	.52	.27	
− .48	.68	.46	
+ .41	.21	.04	
+ .95	.75	.56	
+1.16	.96	.92	
+ .62	.42	.18	
+ .03	.17	.03	
− .59	.79	.62	
		$\Sigma=4.14$	

Extracting the root we find ε_{0+c} or the probable combination and observing error for each direction, on the average, as follows:

	″
East Base	±0.34
West Base	0.28
Burke	0.38
Tunk	0.54
Pigeon	0.34

ε^2_c being known, we form, lastly, $\frac{\varepsilon^2}{m}+\varepsilon^2_c=\varepsilon^2_1$, or the square of the final combination and observing error for any resulting direction, a quantity which we use at once to deduce the relative weights to each direction, and which compares directly with the similar quantity derived from the more direct observations with the thirty-inch theodolite.

Station East Base.

	Mt. Desert.	Burke.	Tunk.	W. Base.	Humpback.	Howard.	Pigeon.
ε^2_{0+c}	0.1178	0.1178	0.1178	0.1178	0.1178	0.1178	0.1178
ε^2	0.0583	0.0499	0.0550	0.0270	0.0477	0.0533	0.0428
$\varepsilon^2_{0+c}-\varepsilon^2=\varepsilon^2_c$	0.0595	0.0679	0.0628	0.0908	0.0701	0.0645	0.0750
$\varepsilon^2_c+\frac{\varepsilon^2}{m}=\varepsilon^2_1$	0.0741	0.0804	0.0766	0.0998	0.0796	0.0823	0.0836
$\varepsilon_1=\pm$	0.″27	0.″28	0.″27	0.″31	0.″28	0.″28	0.″29

(5.) *Resulting horizontal angles from the observations at each station, with their probable errors.*

The figure, the angles of which have to be adjusted, is a nonagon; (see, for instance, Coast Survey Report for 1862, sketch A, Section I.) The angles at the first five stations, viz: East Base, West Base, Burke, Tunk, and Pigeon, which may be called interior with reference to the large quadrilateral formed by Humpback, Desert, Howard, and Cooper, were measured with a repeating circle; the angles of the four stations last named by the great theodolite giving directions. The consecutive numbers attached to the stations will be used hereafter whenever desirable for the sake of brevity. The value of ε_1 is added to each direction.

(1.) EAST BASE, (EPPING,) 1859.

Repeating Theodolite, No. 43.

		° ′ ″	″
7	Desert	0 00 00.00	±0.27
3	Burke	13 34 42.40	0.28
4	Tunk	39 21 25.46	0.27
2	West Base	65 11 55.30	0.31
6	Humpback	92 52 56.31	0.28
8	Howard	235 22 32.46	0.28
5	Pigeon	329 07 59.80	0.29

(2.) WEST BASE, (EPPING,) 1859.

Repeating Theodolite, No. 43.

		° ′ ″	″
1	East Base	0 00 00.00	±0.19
5	Pigeon	64 55 08.30	0.20
3	Burke	89 03 11.75	0.25
4	Tunk	138 04 57.08	0.23
6	Humpback	217 36 38.06	0.24

(3.) BURKE, 1859.

Repeating Theodolite, No. 43.

		° ′ ″	″
6	Humpback	0 00 00.00	±0.32
2	West Base	35 50 55.63	0.36
9	Cooper	62 44 36.70	0.33
1	East Base	75 10 31.48	0.33
8	Howard	105 30 16.64	0.33
5	Pigeon	176 58 51.30	0.34
7	Desert	236 09 13.84	0.34
4	Tunk	315 37 52.99	0.34

(4.) TUNK, 1859.

Repeating Theodolite, No. 43.

		° ′ ″	″
6	Humpback	0 00 00.00	±0.48
2	West Base	67 44 56.53	0.48
1	East Base	83 49 30.54	0.46
3	Burke	118 30 08.38	0.46
5	Pigeon	144 27 29.16	0.46
7	Desert	201 11 04.45	0.47
	Saunders	275 58 53.08	0.51

(5.) PIGEON, 1859.

Repeating Theodolite, No. 43.

		° ′ ″	″
7	Desert	0 00 00.00	±0.27
	Saunders	45 00 42.99	0.29
4	Tunk	74 49 02.86	0.27
3	Burke	90 12 38.14	0.25
6	Humpback	92 09 19.50	0.26
2	West Base	104 56 40.61	0.26
1	East Base	123 57 37.17	0.27
8	Howard	176 41 31.69	0.25

(6.) HUMPBACK, 1858.

Great Theodolite, No. 1.

		° ′ ″	″
9	Cooper	0 00 00.000	±0.150
—	Azimuth mark	39 37 40.230	0.163
8	Howard	39 45 46.385	0.126
1	East Base	59 43 10.401	0.136
2	West Base	69 38 48.051	0.151
5	Pigeon	84 09 57.099	0.125
3	Burke	85 14 25.280	0.142
4	Tunk	102 22 11.498	0.143
7	Desert	114 33 50.877	0.090
	Ragged	154 28 20.545	0.132
	Saunders	165 12 47.118	0.131
	Harris	180 36 29.988	0.169

(7.) DESERT, 1856.

Great Theodolite, No. 1.

		° ′ ″	″
	Isle au Haut	0 00 00.000	±0.141
	Ragged	33 39 21.332	0.108
	Harris	70 54 51.931	0.121
	Saunders	93 48 58.382	0.103
—	Azimuth mark	122 49 25.136	0.098
6	Humpback	144 20 00.152	0.078
4	Tunk	153 19 24.878	0.107
3	Burke	171 09 49.736	0.148
9	Cooper	175 20 34.430	0.115
1	East Base	176 36 26.634	0.132
8	Howard	199 47 46.624	0.132
5	Pigeon	201 46 49.121	0.110

(8.) HOWAR , 1859.

Great Theodoli e, No. 1.

		° ′ ″	″
5	Pigeon	0 00 00.000	±0.140
7	Desert	1 19 25.944	0.177
3	Burke	22 02 34.126	0.213
1	East Base	33 30 40.141	0.191
6	Humpback	51 03 41.505	0.173
9	Cooper	108 01 27.996	0.114
—	Azimuth mark	123 51 19.227	0.110
	Grand Menan	189 28 45.843	0.161

(9.) COOPER, 1859.

Great Theodolite, No. 1.

		° ′ ″	″
	Chamcook	0 00 00.000	±0.117
	Grand Menan	54 40 14.493	0.238
8	Howard	108 56 09.385	0.133
7	Desert	157 47 00.789	0.188
3	Burke	160 11 40.754	0.149
6	Humpback	192 12 43.014	0.259
—	Azimuth mark	294 13 08.804	0.127

(6.) *Effect upon the horizontal angles of a difference of level between the stations occupied and observed upon.*

The effect of a difference of level, h, on the direction, α, of a station in latitude φ equals, (see Lieut. Col. James' English Ordnance Survey, p. 231; also Lieut. Col. Everest's Meridian Arc of India, p. clxvii,) $\frac{e^2 h}{2r \sin 1''} \sin 2\alpha \cos^2 \varphi$, where r represents the earth's equatorial radius, and e the eccentricity.

To examine the greatest effect of the divergence of the plumb-lines at the two stations upon any direction in our figure, we may take $\varphi = 45°$, and $\alpha = 45°$ also.

Elevation of stations above the sea level.

1	East Base	255 feet	By level.
2	West Base	239 feet	By level.
3	Burke	425 feet	Approximately.
4	Tunk	1150 feet	Approximately.
5	Pigeon	315 feet	By level.
6	Humpback	1480 feet	Approximately.
7	Desert	1530 feet	Approximately.
8	Howard	269 feet	By level.
9	Cooper	730 feet	Approximately.

Accordingly the direction from East Base to Desert requires a correction of $+0.''02$; the direction from East Base to Humpback, a correction of $-0.''02$; and the direction of Howard to Desert, a correction of $+0.''015$. The corrections will, therefore, not exceed $0.''02$, which quantity, when compared with the probable error of observation, appears sufficiently small to be neglected in the subsequent reduction of the angles.

(7.) *Spherical excess of triangles.*

The computation of the spherical excess, essential to the establishment of the angle equations, as well as to the proper assignment of weights, as will be shown hereafter, was made by the usual formula,

$$\varepsilon = \frac{ab \sin C}{2r^2 \sin 1''},$$

where a and b represent the triangle sides, including the angle C, and $r^2 = \frac{A^2}{1+e^2 \cos 2L}$, for an azimuth of 45°.

The factor, $\frac{1+e^2 \cos 2L}{2A^2 \sin 1''}$, is taken from the table with the argument L, the latitude of the central point of the surface. The second term of the more complete expression,

$$\varepsilon = \frac{ab \sin C}{2r^2 \sin 1''}\left[1 + \frac{1}{24r^2}(a^2+b^2+c^2)\right],$$

is so small that it can be neglected; in the largest triangle in the quadrilateral, Humpback, Desert, Cooper, and Howard, it amounts to $0.''0001$.

The computed spherical excesses have been checked by adding those of different triangles forming the same surface.

(8.) *Residuals in the sum of the angles of each triangle and their discussion.*

The nonagon around Epping Base includes forty-six triangles; the spherical excess and error, in the closing of each triangle and its square, is contained in the following table. The triangle is denoted by the respective numbers of the three stations, (as stated in art. 5;) the column headed ε contains the spherical excess, and the column headed $S-(180+\varepsilon)$ the error of closing; the last column contains the square of this error. The triangles are arranged in the order of the magnitude of their areas:

Triangle.	ε.	S — 180 — ε.	Square.	Triangle.	ε.	S — 180 — ε.	Square.
	"	"			"	"	
6. 8. 7	8. 799	— 2. 274	5. 1711	4. 6. 5	0. 962	— 0. 763	0. 5822
9. 8. 7	7. 113	— 1. 463	2. 1404	4. 7. 3	0. 892	— 0. 814	0. 6626
6. 9. 7	7. 000	+ 0. 380	0. 1444	5. 4. 2	0. 886	— 1. 726	2. 9791
5. 8. 6	5. 381	— 0. 972	0. 9448	1. 8. 3	0. 812	+ 0. 303	0. 0918
6. 8. 9	5. 314	+ 1. 191	1. 4185	2. 4. 6	0. 804	+ 0. 153	0. 0234
8. 9. 3	4. 678	+ 0. 501	0. 2510	4. 7. 6	0. 772	— 1. 117	1. 2477
9. 6. 3	4. 168	+ 0. 072	0. 0052	6. 5. 2	0. 725	— 0. 807	0. 6512
1. 7. 6	3. 692	— 0. 424	0. 1798	1. 5. 3	0. 592	+ 0. 858	0. 7362
5. 7. 6	3. 605	— 1. 358	1. 8442	3. 4. 6	0. 585	+ 1. 023	1. 0465
3. 8. 6	3. 532	— 0. 618	0. 3819	3. 9. 7	0. 583	+ 1. 216	1. 4786
1. 8. 7	3. 443	— 1. 716	2. 9447	2. 1. 5	0. 533	— 0. 173	0. 0299
3. 8. 7	3. 018	— 0. 748	0. 5595	2. 3. 6	0. 502	— 1. 333	1. 7769
3. 7. 6	2. 248	— 0. 907	0. 8226	1. 7. 3	0. 387	+ 1. 271	1. 6154
1. 8. 5	2. 141	— 0. 140	0. 0196	1. 4. 3	0. 319	— 0. 929	0. 8630
3. 8. 5	1. 921	+ 0. 415	0. 1722	1. 6. 2	0. 317	+ 0. 283	0. 0801
4. 7. 5	1. 871	+ 0. 522	0. 2725	3. 5. 4	0. 305	— 2. 555	6. 5280
1. 8. 6	1. 664	— 0. 134	0. 0180	2. 5. 3	0. 298	+ 1. 292	1. 6693
1. 7. 4	1. 598	— 0. 472	0. 2228	2. 3. 4	0. 283	— 0. 463	0. 2144
1. 5. 6	1. 576	— 0. 698	0. 4872	1. 2. 3	0. 238	+ 0. 262	0. 0686
1. 5. 7	1. 489	— 1. 632	2. 6634	2. 1. 4	0. 203	+ 0. 727	0. 5285
1. 6. 4	1. 323	+ 1. 164	1. 3549	5. 8. 7	0. 187	— 0. 056	0. 0031
5. 3. 7	1. 284	— 1. 219	1. 4860	5. 3. 6	0. 073	+ 0. 768	0. 5898
4. 5. 1	1. 216	— 2. 626	6. 8959				
1. 3. 6	1. 057	— 0. 788	0. 6209				Sum = 54. 4878

Mean error in a triangle, $\sqrt{\frac{54.4878}{46}} = \pm 1.''088$

Probable error in a triangle, ± 0.733

Probable error in an angle, ± 0.423

Probable error in a direction, ± 0.299

These quantities include the errors of observation as well as that arising from the formation of triangles.

If we divide the above residuals into two groups, one with positive, the other with negative signs, we find the sums for the two groups.. $= + 12.402$

in eighteen cases, and.. $= - 28.925$

in twenty-eight cases; the difference,.. 16.523

divided by 46, gives 0.″359; hence, the angles contained in the nonagon are measured, upon the average, too small by 0.″120, which is no doubt due to the use of the repeating theodolite, as a similar examination for angles by the great theodolite proved that there was no bias for this latter instrument.

If we form three groups, arranging the triangles according to their size, we find—

Number.	Error of triangle.	Sum of squares.
1 to 15	5 positive, 10 negative.	16. 98
15 to 30	4 positive, 11 negative.	19. 61
30 to 46	9 positive, 7 negative.	17. 90

From which table it appears that the error in the sum of the angles in the triangles may be taken as independent of the size of the triangle; for the smaller triangles the excess and defect in the sum of the angles appears more balanced.

(9.) *Final determination of probable errors (and weights) to each direction.*

The combination of the angles to triangles introduces a new kind of error which must be taken into account; its general effect is to equalize the weights. This triangle error may be supposed to be principally due to lateral refraction; minor causes may be recognized in the imperfect centering of the theodolite over the same vertical observed upon from the other two stations, and in want of parallelism in the verticals at two stations of unequal elevation, and perhaps in other circumstances. If we separate the observing error, previously deduced from the error obtained in art. (8), we obtain the triangle error. For this purpose the probable observing errors of the 276 directions, forming the geometrical figure under consideration, were tabulated, and the average amount was found to be,

$$\varepsilon_1 = \pm 0.''244.$$

From art. (8) we have, $\varepsilon_{1+\triangle} = \pm 0.299$;

hence, $\varepsilon_\triangle = \sqrt{0.299^2 - 0.244^2} = \pm 0.''173.$

The observing error, therefore, slightly exceeds the triangle error, and shows that the latter cannot be neglected in the true valuation of the respective weights.

The final value of the probable error of any direction in the nonagon we obtain, therefore, by combining the observing and triangle error, the latter being constant. We then have,

$$\varepsilon = \sqrt{\varepsilon^2_1 + \varepsilon^2_\triangle}, \text{ where } \varepsilon^2_\triangle = \pm 0.0299,$$

by which formula the probable errors have been computed. The weight is found by $P = \frac{1}{\varepsilon^2}$.

(10.) *Relative value of results from the thirty-inch and the ten-inch repeating theodolites.*

The relative value of the results by these two instruments is only collateral to the present operations of the treatment of the triangulation. From the values of ε_1, in art. (5), the probable observing error of a resulting direction is, on the average, with the great theodolite, $= \pm 0.''142$, and with the repeating theodolite, $= \pm 0.''321$; the relative weights of the measures by the two instruments, as they have been employed near the Epping Base, are, therefor, on the average as 5 : 1 respectively.

The ratio of the relative weights actually introduced in the conditional equations is, however, less on the average, owing to the equalizing effect of the additional triangle error; the proportion of the greatest to the east weight there equals 7 : 1.

(11.) *Formation of the conditional equations of the nonagon around the Epping Base.*

For a sketch of this part of the primary triangulation, Sketch A, Section I, Coast Survey Report of 1862, may be consulted; the stations will be known by their numbers, as given in art. (5). As the formation of the conditional equations and subsequent processes of the method of least squares is fully explained in Coast Survey Report for 1854, pp. 79* to 86*, a few remarks will suffice here.

The number of angle equations between p, occupied points, and l, full (observed forward and backward) lines, is $l - p + 1 = 21$, and the number of side equations between p, points, (occupied or not,) and l, lines, (full or half full, *i. e.*, observed in both or in one direction only,) is $l - 2p + 3 = 14$. The figure therefore demands thirty-five conditional equations.

The side equations may be formed with the plane or the spherical angles, as the ratios of the sides remain equally true, but the use of the spherical angles was found more direct and simple, and for this reason was preferred, (see on this point Bessel's Gradmessung in Ostpreussen, 1838, p. 140.) The conditional equations were at first established commencing with the primary quadrilateral and working towards the base, but the second method was found preferable, viz., commencing with the base and proceeding outward. In the solution of the conditional equations special regard was had to the derived normal equations, in which the diagonal coefficient should be as large as possible, and the side coefficient as small as possible; the worst conditioned triangles (sum of deviations of each angle from 60° a maximum) and quadrilaterals may be selected; in the latter angles of nearly 90° were avoided, and that station was always selected as pole which either fell within the triangle, (central system,) or which presented the most obtuse angles if outside. Ten-place logarithms (Vega's Thesaurus Logarithmorum Completus, Lipsiae, 1794,) were used in establishing the side equations, and the logarithmic difference is there given in units of the fifth place of decimals, (and not the seventh, as heretofore practiced,) which was found more convenient; for angles greater than 35°, and less than 145°, the logarithmic difference for 10″, as given in the Thesaurus, may be used as correct to the last place; all logarithmic differences for 1″, for small angles, or for angles near 180°, have been specially computed as follows: Let x=small correction (say 1″) to angle a, then $lg \sin (a+x)=lg \sin a+\mathrm{M} \sin 1'' x \operatorname{cotg} a$

where $lg(\mathrm{M} \sin 1'')=4.3233591\ 781$

and for units of the fifth place of decimals, 9.3233592

Conditional equations.

Angle equations:

II. $0=+0.283''+\binom{1}{2}-\binom{6}{2}+\binom{2}{6}-\binom{1}{6}+\binom{6}{1}-\binom{2}{1}$

III. $0=-0.698+\binom{1}{5}-\binom{6}{5}+\binom{5}{6}-\binom{1}{6}+\binom{6}{1}-\binom{5}{1}$

IV. $0=-0.807+\binom{2}{5}-\binom{6}{5}+\binom{5}{6}-\binom{2}{6}+\binom{6}{2}-\binom{5}{2}$

VI. $0=+1.292+\binom{3}{2}-\binom{5}{2}+\binom{2}{5}-\binom{3}{5}+\binom{5}{3}-\binom{2}{3}$

VII. $0=+0.768+\binom{5}{3}-\binom{6}{3}+\binom{3}{6}-\binom{5}{6}+\binom{6}{5}-\binom{3}{5}$

IX. $0=-0.788+\binom{1}{3}-\binom{6}{3}+\binom{3}{6}-\binom{1}{6}+\binom{6}{1}-\binom{3}{1}$

XI. $0=-2.555+\binom{4}{3}-\binom{5}{3}+\binom{3}{5}-\binom{4}{5}+\binom{5}{4}-\binom{3}{4}$

XII. $0=-1.726+\binom{5}{4}-\binom{2}{4}+\binom{4}{2}-\binom{5}{2}+\binom{2}{5}-\binom{4}{5}$

XIV. $0=-0.929+\binom{1}{3}-\binom{4}{3}+\binom{3}{4}-\binom{1}{4}+\binom{4}{1}-\binom{3}{1}$

XVI. $0=+0.153+\binom{4}{6}-\binom{2}{6}+\binom{6}{2}-\binom{4}{2}+\binom{2}{4}-\binom{6}{4}$

XVIII. $0=-0.907+\binom{6}{3}-\binom{7}{3}+\binom{3}{7}-\binom{6}{7}+\binom{7}{6}-\binom{3}{6}$

XIX. $0=-1.117+\binom{7}{6}-\binom{4}{6}+\binom{6}{4}-\binom{7}{4}+\binom{4}{7}-\binom{6}{7}$

XXI. $0=+1.271+\binom{3}{1}-\binom{7}{1}+\binom{1}{7}-\binom{3}{7}+\binom{7}{3}-\binom{1}{3}$

XXIII. $0=-1.358+\binom{6}{5}-\binom{7}{5}+\binom{5}{7}-\binom{6}{7}+\binom{7}{6}-\binom{5}{6}$

XXV. $0=+0.303+\binom{3}{1}-\binom{8}{1}+\binom{1}{8}-\binom{3}{8}+\binom{8}{3}-\binom{1}{3}$

XXVI. $0=-0.134+\binom{1}{6}-\binom{8}{6}+\binom{6}{8}-\binom{1}{8}+\binom{8}{1}-\binom{6}{1}$

XXVIII. $0=-1.716+\binom{7}{1}-\binom{8}{1}+\binom{1}{8}-\binom{7}{8}+\binom{8}{7}-\binom{1}{7}$

XXX. $0=-0.056+\binom{8}{5}-\binom{7}{5}+\binom{5}{7}-\binom{8}{7}+\binom{7}{8}-\binom{5}{8}$

XXXII. $0=+1.216+\binom{7}{3}-\binom{9}{3}+\binom{3}{9}-\binom{7}{9}+\binom{9}{7}-\binom{3}{7}$

XXXIII. $0=+0.380+\binom{7}{6}-\binom{9}{6}+\binom{6}{9}-\binom{7}{9}+\binom{9}{7}-\binom{6}{7}$

XXXV. $0=-1.463+\binom{8}{7}-\binom{9}{7}+\binom{7}{9}-\binom{8}{9}+\binom{9}{8}-\binom{7}{8}$

Side equations:

I. $$\begin{aligned}0=&+2.17807+0.40132\binom{6}{1}-0.37895\binom{2}{1}+0.61094\binom{1}{5}-1.53850\binom{2}{5}+0.81302\binom{5}{6}-2.01607\binom{2}{6}\\&+2.20305\binom{1}{6}-0.02237\binom{5}{1}+0.92756\binom{6}{5}\end{aligned}$$

V. $$\begin{aligned}0=&-6.12588+0.80064\binom{2}{5}+5.39998\binom{3}{5}+10.47161\binom{3}{6}-11.22604\binom{5}{6}-6.20062\binom{6}{5}+0.75443\binom{2}{6}\\&-0.16782\binom{6}{2}-0.30212\binom{3}{2}+0.46994\binom{5}{2}\end{aligned}$$

VIII. $$\begin{aligned}0=&+0.08483+0.25700\binom{1}{3}-0.54841\binom{2}{3}+0.29141\binom{6}{3}+0.75443\binom{3}{6}-1.95748\binom{2}{6}+1.20305\binom{1}{6}\\&+0.40132\binom{6}{1}+0.16676\binom{3}{1}-0.56808\binom{2}{1}\end{aligned}$$

X. $$\begin{aligned}0=&-1.34263+0.18284\binom{4}{2}-0.65278\binom{3}{2}+0.46994\binom{5}{2}+0.80064\binom{2}{5}-1.56540\binom{3}{5}+0.76476\binom{4}{5}\\&+0.43254\binom{5}{4}-0.60454\binom{3}{4}+0.17200\binom{2}{4}\end{aligned}$$

XIII. $$\begin{aligned}0=&-0.68771+0.31512\binom{1}{5}-1.07988\binom{3}{5}+0.76476\binom{4}{5}+0.43254\binom{5}{4}-0.73688\binom{3}{4}+0.30434\binom{1}{4}\\&+0.43596\binom{4}{1}-0.65063\binom{3}{1}+0.21467\binom{5}{1}\end{aligned}$$

XV. $$\begin{aligned}0=&-1.58338+0.73062\binom{1}{4}-0.81676\binom{2}{4}+0.08614\binom{6}{4}+0.32768\binom{4}{6}-1.53073\binom{2}{6}+1.20305\binom{1}{6}\\&+0.40132\binom{6}{1}-0.83606\binom{2}{1}+0.43474\binom{4}{1}\end{aligned}$$

XVII. $$\begin{aligned}0=&+0.22432+0.65422\binom{3}{7}-1.98508\binom{4}{7}+1.33086\binom{6}{7}+0.97432\binom{7}{6}-1.65748\binom{4}{6}+0.68316\binom{3}{6}\\&+0.21525\binom{6}{3}-0.25436\binom{4}{3}+0.03911\binom{7}{3}\end{aligned}$$

XX. $$\begin{aligned}0=&-1.83218+2.20947\binom{1}{7}-2.62575\binom{3}{7}+0.41628\binom{6}{7}+0.37484\binom{7}{6}-0.81586\binom{3}{6}+0.44102\binom{1}{6}\\&+0.03977\binom{6}{1}-0.91152\binom{3}{1}+0.87175\binom{7}{1}\end{aligned}$$

XXII. $$\begin{aligned}0=&-0.44146+0.67443\binom{6}{5}-0.73156\binom{4}{5}+0.05713\binom{7}{5}+0.18656\binom{5}{7}-1.51742\binom{4}{7}+1.33086\binom{6}{7}\\&+0.97432\binom{7}{6}-1.61457\binom{4}{6}+0.64025\binom{5}{6}\end{aligned}$$

XXIV. $$\begin{aligned}0=&+0.92970+0.44102\binom{3}{6}-1.02088\binom{1}{6}+0.57986\binom{8}{6}+0.66575\binom{6}{8}-1.70358\binom{1}{8}+1.03783\binom{3}{8}\\&+0.35990\binom{8}{3}-0.41562\binom{1}{3}+0.05572\binom{6}{3}\end{aligned}$$

XXVII. $$\begin{aligned}0=&-1.36912+0.66575\binom{6}{8}-1.00027\binom{1}{8}+0.33452\binom{7}{8}+0.49153\binom{8}{7}-0.82493\binom{1}{7}+0.33340\binom{6}{7}\\&+0.14829\binom{7}{6}-0.72815\binom{1}{6}+0.57986\binom{8}{6}\end{aligned}$$

XXIX. $$\begin{aligned}0=&+0.51527+0.35890\binom{7}{6}-0.57388\binom{5}{6}+0.21498\binom{8}{6}+0.17014\binom{6}{8}+8.94070\binom{5}{8}-9.11084\binom{7}{8}\\&+5.94358\binom{5}{7}-6.07800\binom{8}{7}+0.13442\binom{6}{7}\end{aligned}$$

XXXI. $$\begin{aligned}0=&-1.75954+0.33673\binom{6}{9}-5.33719\binom{3}{9}+5.00046\binom{7}{9}+2.88157\binom{9}{7}+3.29785\binom{3}{7}+0.41628\binom{6}{7}\\&+0.37484\binom{7}{6}-0.39237\binom{3}{6}+0.01753\binom{9}{6}\end{aligned}$$

XXXIV. $$\begin{aligned}0=&+0.82217+4.83153\binom{3}{9}-5.00046\binom{7}{9}+0.16893\binom{8}{9}+0.01479\binom{9}{8}-0.57145\binom{3}{8}+0.55666\binom{7}{8}\\&+0.38566\binom{8}{7}+2.49591\binom{3}{7}-2.88157\binom{9}{7}\end{aligned}$$

In the equations of correlatives four places of decimals have been retained.

(12.) *Equations of correla*

The fifty-eight equations of correlatives, and

Equations of

$\bar{P}=E^2$.	v.	II.	III.	IV.	VI.	VII.	IX.	XI.	XII.	XIV.	XVI.	XVIII.	XIX.	XXI.	XXIII.	XXV.	XXVI.	XXVIII.	XXX.	XXXII.	XXXIII.	XXXV.	I.
0.128	$(\frac{2}{1})$	−1																					−0.3790
0.108	$(\frac{3}{1})$						−1			−1				+1		+1							
0.105	$(\frac{4}{1})$									+1													
0.112	$(\frac{5}{1})$		−1																				−0.0224
0.108	$(\frac{6}{1})$	+1	+1				+1										−1						+0.4013
0.102	$(\frac{7}{1})$													−1				+1					
0.110	$(\frac{8}{1})$															−1	+1	−1					
0.065	$(\frac{1}{2})$	+1																					
0.093	$(\frac{3}{2})$				+1																		
0.084	$(\frac{4}{2})$								+1		−1												
0.070	$(\frac{5}{2})$			−1	−1				−1														
0.087	$(\frac{6}{2})$	−1		+1							+1												
0.139	$(\frac{1}{3})$						+1			+1				−1		−1							
0.157	$(\frac{2}{3})$				−1																		
0.146	$(\frac{4}{3})$							+1		−1													
0.148	$(\frac{5}{3})$				+1	+1		−1															
0.132	$(\frac{6}{3})$					−1	−1					+1											
0.144	$(\frac{7}{3})$											−1		+1						+1			
0.142	$(\frac{8}{3})$															+1							
0.138	$(\frac{9}{3})$																			−1			
0.237	$(\frac{1}{4})$									−1													
0.256	$(\frac{2}{4})$								−1		+1												
0.241	$(\frac{3}{4})$							−1		+1													
0.239	$(\frac{5}{4})$							+1	+1														
*0.259	$(\frac{6}{4})$										−1		+1										
0.250	$(\frac{7}{4})$												−1										
0.102	$(\frac{1}{5})$		+1																				+0.6109
0.098	$(\frac{2}{5})$			+1	+1				+1														−1.5385
0.094	$(\frac{3}{5})$				−1	−1		+1															
0.104	$(\frac{4}{5})$							−1	−1														
0.098	$(\frac{6}{5})$		−1	−1		+1									+1								+0.9276
0.105	$(\frac{7}{5})$														−1				−1				
0.094	$(\frac{8}{5})$																		+1				
0.049	$(\frac{1}{6})$	−1	−1				−1										+1						+1.2030
0.053	$(\frac{2}{6})$	+1		−1							−1												−2.0161
0.050	$(\frac{3}{6})$					+1	+1					−1											
0.051	$(\frac{4}{6})$										+1		−1										
0.046	$(\frac{5}{6})$		+1	+1		−1									−1								+0.8130
0.038	$(\frac{7}{6})$											+1	+1		+1						+1		
0.046	$(\frac{8}{6})$																−1						
0.053	$(\frac{9}{6})$																				−1		
0.048	$(\frac{1}{7})$													+1				−1					
0.052	$(\frac{3}{7})$											+1		−1						−1			
0.042	$(\frac{4}{7})$												+1										
0.042	$(\frac{5}{7})$														+1				+1				
†0.036	$(\frac{6}{7})$											−1	−1		−1						−1		
0.048	$(\frac{8}{7})$																	+1	−1			+1	
0.043	$(\frac{9}{7})$																			+1	+1	−1	
0.067	$(\frac{1}{8})$															+1	−1	+1					
0.076	$(\frac{3}{8})$															−1							
0.050	$(\frac{5}{8})$																		−1				
0.060	$(\frac{6}{8})$																+1						
0.062	$(\frac{7}{8})$																	−1	+1			−1	
0.043	$(\frac{9}{8})$																					+1	
0.052	$(\frac{3}{9})$																			+1			
0.097	$(\frac{6}{9})$																				+1		
0.066	$(\frac{7}{9})$																			−1	−1	+1	
0.048	$(\frac{8}{9})$																					−1	

* Maximum. † Minimum.

tives and normal equations.

thirty-five normal equations, are as follows:

correlatives.

V.	VIII.	X.	XIII.	XV.	XVII.	XX.	XXII.	XXIV.	XXVII.	XXIX.	XXXI.	XXXIV.
	−0.5681			−0.8361								
	+0.1668		−0.6506			−0.9115						
			+0.4360	+0.4347								
			+0.2147									
	+0.4013			+0.4013		+0.0398						
						+0.8718						
− 0.3021		−0.6528										
		+0.1828										
+ 0.4699		+0.4699										
− 0.1678												
	+0.2570							−0.4156				
	−0.5484											
					−0.2544							
	+0.2914				+0.2153			+0.0557				
					+0.0391							
								+0.3559				
			+0.3043	+0.7306								
		+0.1720		−0.8168								
		−0.6045	−0.7369									
		+0.4325	+0.4325									
				+0.0861								
			+0.3151									
+ 0.8006		+0.8006										
+ 5.4000		−1.5654	−1.0799									
		+0.7648	+0.7648				−0.7316					
− 6.2006							+0.6744					
							+0.0571					
	+1.2030			+1.2030		+0.4410		−1.0209	−0.7282			
+ 0.7544	−1.9575			−1.5307								
+10.4716	+0.7544				+0.6832	−0.8159		+0.4410			−0.3924	
				+0.3277	−1.6575		−1.6146					
−11.2260							+0.6403			−0.5739		
					+0.9743	+0.3748	+0.9743		+0.1483	+0.3589	+0.3748	
								+0.5799	+0.5799	+0.2150		
											+0.0175	
						+2.2095			−0.8249			
					+0.6542	−2.6258					−3.2978	+2.4959
					−1.9851		−1.5174					
							+0.1866			+5.9436		
					+1.3309	+0.4163	+1.3309		+0.3334	+0.1344	+0.1463	
									+0.4915	−6.0780		+0.3857
											+2.8816	−2.8816
								−1.7036	−1.0003			
								+1.0378				−0.5715
										+8.9407		
								+0.6658	+0.6658	+0.1701		
									+0.3345	−9.1108		+0.5567
												+0.0148
											−5.3372	+4.8315
											+0.3367	
											+5.0005	−5.0005
												+0.1689

Normal equations.

	II.	III.	IV.	VI.	VII.	IX.	XI.	XII.	XIV.	XVI.	XVIII.	XIX.	XXI.	XXIII.	XXV.	XXVI.	XXVIII.	XXX.
0=																		
+0.283	+0.490	+0.157	−0.140			+0.157				−0.140						−0.157		
−0.698	+0.157	+0.515	+0.144		−0.144	+0.157								−0.144		−0.157		
−0.807	−0.140	+0.144	+0.452	+0.168	−0.144			+0.168		+0.140				−0.144				
+1.292			+0.168	+0.660	+0.242		−0.242	+0.168										
+0.768		−0.144	−0.144	+0.242	+0.568	+0.182	−0.242				−0.182			+0.144				
−0.788	+0.157	+0.157			+0.182	+0.586			+0.247		−0.182		−0.247		−0.247	−0.157		
−2.555				−0.242	−0.242		+0.972	+0.343	−0.387									
−1.726			+0.168	+0.168			+0.343	+0.851		−0.340								
−0.929						+0.247	−0.387		+0.976				−0.247		−0.247			
+0.153	−0.140		+0.140					−0.340		+0.790		−0.310						
−0.907					−0.182	−0.182					+0.452	+0.074	−0.196	+0.074				
−1.117										−0.310	+0.074	+0.676		+0.074				
+1.271						−0.247			−0.247		−0.196		+0.593		+0.247		−0.150	
−1.358		−0.144	−0.144		+0.144						+0.074	+0.074		+0.365				+0.147
+0.303						−0.247			−0.247				+0.247		+0.642	−0.177	+0.177	
−0.134	−0.157	−0.157				−0.157									−0.177	+0.440	−0.177	
−1.716													−0.150		+0.177	−0.177	+0.437	−0.110
−0.056														+0.147			−0.110	+0.401
+1.216											−0.196		+0.196					
+0.380											+0.074	+0.074		+0.074				
−1.463																	+0.110	−0.110
+2.1781	−0.0740	−0.0043	−0.0974	−0.1508	+0.0535	−0.0156		−0.1508		+0.1069				+0.0535		+0,0156		
6.1259	+0.0546	+0.0913	+0.0823	−0.4901	−0.0753	+0.5236	+0.5076	+0.0456		−0.0546	−0.5236			−0.0913				
+0.0848	−0.0466	−0.0156	+0.1037	+0.0861	−0.0007	+0.0013			+0.0177	+0.1037	+0.0007		−0.0177		−0.0177	+0.0156		
−1.3426			+0.0456	+0.1320	+0.1472		+0.0224	+0.0407	−0.1457	+0.0287								
−0.6877		+0.0081		+0.1015	+0.1015	+0.0703	+0.0999	+0.0238	−0.1337				−0.0703		−0.0703			
−1.5834	+0.0103	−0.0156	+0.0811			−0.0156		+0.2091	−0.1275	−0.1335		+0.0056				+0.0156		
+0.2243					+0.0057	+0.0057	−0.0371		+0.0371	−0.0845	+0.0118	−0.0097	−0.0284	−0.0109				
−1.8322	−0.0173	−0.0173			−0.0408	+0.0403			+0.0984		−0.0965	−0.0007	+0.0552	−0.0007	−0.0984	+0.0173	−0.0171	
−0.4415		−0.0366	−0.0366		+0.0366		+0.0761	+0.0761		−0.0823	−0.0109	+0.0077		+0.0276				+0.0018
+0.9297	+0.0500	+0.0500			+0.0147	+0.0070			−0.0578		−0.0147		+0.0578		−0.0841	+0.0774	−0.1141	
−1.3691	−0.0357	+0.0357				+0.0357					−0.0064	−0.0064	−0.0396	−0.0064	−0.0670	+0.0446	−0.0246	−0.0028
+0.5153		−0.0264	−0.0264		+0.0264						+0.0088	+0.0088		+0.2848		+0.0003	+0.2731	−0.4705
−1.7595					−0.0196	−0.0196					−0.1526	−0.0007	+0.1715	−0.0007				
+0.8222											+0.1298		−0.1298		+0.0434		−0.0160	+0.0160

Normal equations—Continued.

XXXII.	XXXIII.	XXXV.	I.	V.	VIII.	X.	XIII.	XV.	XVII.	XX.	XXII.	XXIV.	XXVII.	XXIX.	XXXI.	XXXIV.
			−0.0740	+ 0.0546	−0.0466			+0.0103		−0.0173		+0.0500	+0.0357			
			−0.0043	+ 0.0913	−0.0156		+0.0081.	−0.0156		−0.0173	−0.0366	+0.0500	+0.0357	−0.0264		
			−0.0974	+ 0.0823	+0.1037	+0.0456		+0.0811			−0.0366			−0.0264		
			−0.1508	− 0.4901	+0.0861	+0.1320	+0.1015									
			+0.0535	− 0.0753	−0.0007	+0.1472	+0.1015		+0.0057	−0.0408	+0.0366	+0.0147		+0.0264	−0.0196	
			−0.0156	+ 0.5236	+0.0013		+0.0703	−0.0156	+0.0057	+0.0403		+0.0070	+0.0357		−0.0196	
				+ 0.5076		+0.0224	+0.0999		−0.0371		+0.0761					
			−0.1508	+ 0.0456		+0.0407	+0.0238	+0.2091			+0.0761					
					+0.0177	−0.1457	−0.1337	−0.1275	+0.0371	+0.0984		−0.0578				
			+0.1069	− 0.0546	+0.1037	+0.0287		−0.1335	−0.0845		−0.0823					
−0.196	+0.074			− 0.5236	+0.0007				+0.0118	−0.0965	−0.0109	−0.0147	−0.0064	+0.0088	−0.1526	+0.1298
	+0.074							+0.0056	−0.0097	−0.0007	+0.0077		−0.0064	+0.0088	−0.0007	
+0.196					−0.0177		−0.0703		−0.0284	+0.0552		+0.0578	−0.0396		+0.1715	−0.1298
	+0.074		+0.0535	− 0.0913					−0.0109	−0.0007	+0.0276		−0.0064	+0.2848	−0.0007	
					−0.0177		−0.0703			−0.0984		−0.0841	−0.0670			+0.0434
			+0.0156		+0.0156			+0.0156		+0.0173		+0.0774	+0.0446	+0.0003		
		+0.110								−0.0171		−0.1141	−0.0246	+0.2731		−0.0160
		−0.110									+0.0018		−0.0028	−0.4705		+0.0160
+0.495	+0.109	−0.109							−0.0284	+0.1365					−0.3122	+0.3276
+0.109	+0.333	−0.109							−0.0109	−0.0007	−0.0109		−0.0064	+0.0088	−0.1751	+0.2061
−0.109	−0.109	+0.310											+0.0028	+0.2731	+0.2061	−0.2296
			+0.7070	− 1.1848	+0.3250	−0.1207	+0.0191	+0.2924		+0.0277	+0.0853	−0.0602	−0.0429	−0.0215		
			−1.1848	+17.9078	+0.3167	−0.6980	−0.5481	−0.0612	+0.3577	−0.4272	−0.7404	+0.2309		+0.2964	−0.2054	
			+0.3250	+ 0.3167	+0.4318		−0.0117	+0.3079	+0.0341	−0.0195		−0.0563	−0.0429		−0.0148	
			−0.1207	− 0.6980		+0.5521	+0.3718	−0.0360			−0.0582					
			+0.0191	− 0.5481	−0.0117	+0.3718	+0.4489	+0.0726		+0.0640	−0.0582					
			+0.2924	− 0.0612	+0.3079	−0.0360	+0.0726	+0.6265	−0.0277	+0.0277	−0.0270	−0.0602	−0.0429			
−0.0284	−0.0109			+ 0.3577	+0.0341			−0.0277	+0.4668	−0.0834	+0.3628	+0.0166	+0.0215	+0.0197	−0.0917	+0.0849
+0.1365	−0.0007		+0.0277	− 0.4272	−0.0195		+0.0640	+0.0277	−0.0834	+0.8147	+0.0338	−0.0400	−0.0961	+0.0071	+0.4779	−0.3408
	−0.0109		+0.0853	− 0.7404		−0.0582	−0.0582	−0.0270	+0.3628	+0.0338	+0.4505		+0.0215	+0.0494	+0.0338	
			−0.0602	+ 0.2309	−0.0563			−0.0602	+0.0166	−0.0400		+0.4220	+0.1927	+0.0125	−0.0087	−0.0451
	−0.0064	+0.0028	−0.0429		−0.0429			−0.0429	+0.0215	−0.0961	+0.0215	+0.1927	+0.1911	−0.3162	+0.0071	+0.0206
	+0.0088	+0.2731	−0.0215	+ 0.2964					+0.0197	+0.0071	+0.0494	+0.0125	−0.3162	+12.4247	+0.0071	−0.4270
−0.3122	−0.1751	+0.2061		− 0.2054	−0.0148				−0.0917	+0.4779	+0.0338	−0.0087	+0.0071	+0.0071	+4.0844	−3.7763
+0.3276	+0.2061	−0.2296							+0.0849	−0.3408		−0.0451	+0.0206	−0.4270	−3.7763	+3.5977

The solution of the normal equations was effected by application of the method of indirect elimination, (Coast Survey Report of 1855, Appendix No. 40,) and was broken off after securing the perfect adjustment of the hundredths of seconds in the angles, and nearly the last unit in the seventh place of logarithms of length of sides. The computation of the forty-six triangles showed that the remaining difference in the sum of the angles was, upon the average, a little less than 0.″003, and in maximo it amounted to 0.″007, which was thought to be a sufficiently close adjustment, considering that the measured angles, with the repeating theodolite, are only given to the nearest, 0.″01 in the abstract, and are liable to an average probable error of $\pm$ 0.″45; the angles measured with the great theodolite have an average probable error of $\pm$ 0.″20, (as found from the probable error of the directions in preceding abstract of angles, art. 5.) The logarithms of the distances show a corresponding degree of differences from the mean, amounting, upon the average, to less than a unit in the seventh place of decimals, and in maximo to two units in that place, the uncertainty in the measure of the base being nearly $\frac{1}{550000}$ of its length; the logarithm of the base is uncertain by eight units in the seventh place of decimals. It might be remarked in this place that—

Of 15 sides we have 4 independent values for each.
Of 8 sides we have 3 independent values for each.
Of 3 sides we have 2 independent values for each.
Of 3 sides we have 1 independent value for each.

Table of correlatives resulting from the solution of the normal equations.

II	= − 3.358	XXXII	= − 7.795
III	+ 8.923	XXXIII	+ 3.280
IV	+ 1.421	XXXV	− 1.168
VI	− 12.538	I	− 21.566
VII	+ 12.900	V	− 0.485
IX	− 1.519	VIII	+ 18.103
XI	+ 3.839	X	− 8.428
XII	− 3.486	XIII	+ 11.827
XIV	+ 4.992	XV	+ 3.918
XVI	− 0.995	XVII	− 10.152
XVIII	+ 8.987	XX	+ 12.972
XIX	− 0.252	XXII	+ 12.028
XXI	+ 13.227	XXIV	− 29.368
XXIII	+ 2.295	XXVII	+ 51.563
XXV	+ 3.565	XXIX	− 0.0271
XXVI	+ 4.168	XXXI	− 24.943
XXVIII	+ 3.903	XXXIV	− 35.537
XXX	+ 1.732		

(13.) *Resulting corrections to the observed directions.*

Substituting the above in the weighted equations of correlatives, we obtain the following corrections to the observed directions:

″	″	″	″	″	″	″	″	″
$\binom{2}{1}$ = − 0.260	$\binom{1}{2}$ = − 0.218	$\binom{1}{3}$ = + 0.492	$\binom{1}{4}$ = + 0.348	$\binom{1}{5}$ = − 0.053	$\binom{1}{6}$ = − 0.058	$\binom{1}{7}$ = − 0.218	$\binom{1}{8}$ = + 0.117	$\binom{3}{9}$ = + 0.364
$\binom{3}{1}$ − 0.343	$\binom{3}{2}$ − 0.641	$\binom{2}{3}$ + 0.410	$\binom{2}{4}$ − 0.553	$\binom{2}{5}$ + 1.121	$\binom{2}{6}$ − 0.111	$\binom{3}{7}$ − 0.552	$\binom{2}{8}$ − 1.044	$\binom{6}{9}$ − 0.823
$\binom{4}{1}$ + 1.244	$\binom{4}{2}$ − 0.339	$\binom{4}{3}$ + 0.209	$\binom{3}{4}$ − 0.595	$\binom{3}{5}$ + 0.120	$\binom{3}{6}$ − 0.289	$\binom{4}{7}$ + 0.069	$\binom{5}{8}$ − 0.099	$\binom{7}{9}$ + 0.417
$\binom{5}{1}$ − 0.661	$\binom{5}{2}$ + 0.729	$\binom{5}{3}$ − 0.515	$\binom{5}{4}$ + 0.436	$\binom{4}{5}$ − 0.681	$\binom{4}{6}$ − 0.105	$\binom{5}{7}$ + 0.257	$\binom{6}{8}$ + 1.136	$\binom{8}{9}$ − 0.232
$\binom{6}{1}$ + 0.062	$\binom{6}{2}$ + 0.336	$\binom{6}{3}$ − 0.124	$\binom{6}{4}$ + 0.280	$\binom{6}{5}$ − 0.395	$\binom{5}{6}$ − 0.424	$\binom{6}{7}$ − 0.136	$\binom{7}{8}$ − 0.204	
$\binom{7}{1}$ + 0.202		$\binom{7}{3}$ − 0.569	$\binom{7}{4}$ + 0.063	$\binom{7}{5}$ − 0.351	$\binom{7}{6}$ + 0.590	$\binom{8}{7}$ + 0.615	$\binom{9}{8}$ − 0.073	
$\binom{8}{1}$ − 0.363		$\binom{8}{3}$ − 0.995		$\binom{8}{5}$ + 0.163	$\binom{8}{6}$ + 0.400	$\binom{9}{7}$ − 0.070		
		$\binom{9}{3}$ + 1.076			$\binom{9}{6}$ − 0.206			

If we form the squares of these corrections, and divide their sum by 58, we find the average square, and by extracting the root we obtain the average correction to a direction, as demanded by the geometrical conditions of the figure,

$$\sqrt{\frac{15.0199}{58}} = \pm 0.''509 \text{ for a direction, and}$$

$$\pm 0.720 \text{ for an angle;}$$

values much greater than those resulting from the errors in the measures at any one station, or from their combinations to form triangles, (compare with ε_1 and $\varepsilon_{1+\Delta}$ of art. 9.) The error, therefore, arising from a want of perfect intersection of the lines of sight at any one station is the greatest; it may be called "intersection error." This consideration shows that we have even now too much diversity in our assigned weights in the equations of correlatives.

(14.) *Complete adjustment of the nonagon and final directions.*

For the subsequent computation of the triangle sides and the introduction and discussion of the astronomical azimuths, it is desirable to have the adjustment of the whole figure perfect, the triangles to 0.″001, and the logarithmic distances to the eighth place of decimals; an additional differential or second order adjustment by least squares of the remaining small discrepancies, neglecting weights, was therefore added to the preceding general adjustment. For this purpose the figure was divided into three parts, and each adjusted separately, without reacting on the preceding. The first part comprised the base pentagon, which forms a separate system, the angles of which were measured by repetition; it involved nine conditional equations between the second-order discrepancies, (or six angle and three side equations;) the second part connects the pentagon with the side Humpback–Desert by means of fourteen equations, (eight angle and six side equations;) the third part joins the last points, Howard and Cooper, to the preceding figure by means of twelve equations, (seven angle and five side equations.) As this secondary process involves no new feature, the resulting small additional corrections to each direction, resulting from it, are at once presented in the table below; these should be added to the corrections given in the preceding article:

	″		″		″
$(^{2}_{1}$ =	− 0.003	$(^{6}_{1}$ =	− 0.006	$(^{8}_{1}$ =	− 0.006
$(^{3}_{1}$	0.000	$(^{7}_{1}$	+ 0.011	$(^{8}_{3}$	− 0.013
$(^{4}_{1}$	+ 0.004	$(^{6}_{2}$	− 0.005	$(^{9}_{3}$	− 0.015
$(^{5}_{1}$	− 0.004	$(^{5}_{3}$	+ 0.007	$(^{8}_{5}$	+ 0.016
$(^{1}_{2}$	− 0.002	$(^{7}_{3}$	+ 0.010	$(^{8}_{6}$	+ 0.009
$(^{3}_{2}$	− 0.001	$(^{6}_{4}$	+ 0.001	$(^{9}_{6}$	+ 0.010
$(^{4}_{2}$	− 0.003	$(^{7}_{4}$	− 0.006	$(^{8}_{7}$	− 0.002
$(^{5}_{2}$	+ 0.002	$(^{6}_{5}$	+ 0.005	$(^{9}_{7}$	− 0.005
$(^{1}_{3}$	0.000	$(^{7}_{5}$	− 0.006	$(^{1}_{8}$	− 0.002
$(^{2}_{3}$	+ 0.002	$(^{1}_{6}$	− 0.003	$(^{3}_{8}$	− 0.012
$(^{4}_{3}$	0.000	$(^{2}_{6}$	− 0.001	$(^{5}_{8}$	+ 0.010
$(^{5}_{3}$	+ 0.001	$(^{3}_{6}$	+ 0.007	$(^{6}_{8}$	+ 0.007
$(^{1}_{4}$	+ 0.003	$(^{4}_{6}$	+ 0.002	$(^{7}_{8}$	+ 0.003
$(^{2}_{4}$	− 0.002	$(^{5}_{6}$	+ 0.005	$(^{9}_{8}$	+ 0.007
$(^{3}_{4}$	+ 0.001	$(^{7}_{6}$	− 0.007	$(^{3}_{9}$	− 0.012
$(^{5}_{4}$	− 0.001	$(^{1}_{7}$	+ 0.013	$(^{6}_{9}$	+ 0.010
$(^{1}_{5}$	− 0.001	$(^{3}_{7}$	+ 0.010	$(^{7}_{9}$	− 0.002
$(^{2}_{5}$	+ 0.004	$(^{4}_{7}$	− 0.006	$(^{8}_{9}$	+ 0.006
$(^{3}_{5}$	0.000	$(^{5}_{7}$	− 0.010		
$(^{4}_{5}$	− 0.002	$(^{6}_{7}$	− 0.007		

The following table contains the adjusted directions at each station:

1. EAST BASE.		2. WEST BASE.		3. BURKE.		4. TUNK.		5. PIGEON.	
	° ′ ″		° ′ ″		° ′ ″		° ′ ″		° ′ ″
7	0 00 00.000	1	0 00 00.000	6	0 00 00.000	6	0 00 00.000	7	0 00 00.000
3	13 34 41.844	5	64 55 09.251	2	35 50 56.159	2	67 44 55.694	4	74 49 02.534
4	39 21 26.495	3	89 03 11.328	9	62 44 37.879	1	83 49 30.610	3	90 12 38.617
2	65 11 54.824	4	138 04 56.958	1	75 10 32.089	3	118 30 07.505	6	92 09 19.467
6	92 52 56.153	6	217 36 38.611	8	105 30 15.749	5	144 27 29.314	2	104 56 42.092
8	235 22 31.878			5	176 58 50.903	7	201 11 04.226	1	123 57 37.473
5	329 07 58.922			7	236 09 13.398			8	176 41 32.226
				4	315 37 53.316				

6. HUMPBACK.		7. DESERT.		8. HOWARD.		9. COOPER.	
	° ′ ″		° ′ ″		° ′ ″		° ′ ″
9	0 00 00.000	6	0 00 00.000	5	0 00 00.000	8	0 00 00.000
Az. m.	39 37 40.403	4	8 59 24.932	7	1 19 25.832	7	48 50 52.045
8	39 45 46.990	3	26 49 49.185	3	22 02 33.158	3	51 15 31.948
1	59 43 10.536	9	31 00 34.346	1	33 30 40.345	6	83 16 33.042
2	69 38 48.135	1	32 16 26.420	6	51 03 42.737	Az. m.	185 16 59.577
5	84 09 56.876	8	55 27 47.228	9	108 01 28.018		
3	85 14 25.195	5	57 26 49.358	Az. m.	123 51 19.290		
4	102 22 11.591	Az. m.	338 29 25.121				
7	114 33 51.656						

(15.) *Triangle side computations.*

The arrangement of the triangle side computations is the usual one followed in the Coast Survey. I have, however, introduced a new and less complex notation than Gerling's for the distances: thus, to express the distance from station 1 to station 2, I write, 1..2. On the first line we have the given side, the left-hand (as seen from the opposite angle) station being given first. The first column contains the number of the triangle; the second column the name, and the third the respective number of each station, that opposite the base being given first; the fourth column contains the observed angles—that is, the results found from the adjustment of the measures at each station, given in art. 5; the fifth column contains the correction due to the conditions of the geometrical figure, and derived from arts. 13 and 14; the sixth column shows the corrected spherical angles; the seventh the spherical excess, and the eighth the plane angles; the last column contains the logarithms of angles and sides. By Legendre's theorem, after deducting one-third of the spherical excess of the triangle from each spherical angle, A, B, C, the triangle can be treated as a plane one for the computation of the lengths of the sides, a b, which is readily done by the formulæ—

$$a = c \sin\left(A-\frac{\varepsilon}{3}\right) \operatorname{cosec}\left(C-\frac{\varepsilon}{3}\right),$$

$$b = c \sin\left(B-\frac{\varepsilon}{3}\right) \operatorname{cosec}\left(C-\frac{\varepsilon}{3}\right),$$

the measured or derived base, c, being known. The fifth and sixth lines contain the logarithms of the distances. It will be seen that the whole process is carried out systematically.

The value here given for the measured length of the Epping Base is not final, but may receive a small change due to additional experiments of comparisons; its unit is the length of the metre of the committee of weights and measures of Paris, 1799.

The angles being made out and adjusted to thousandths of seconds, the corresponding number of decimals to be retained in the logarithms of the distances is eight; these distances were, however, originally made out to ten places by means of Vega's Thesaurus.

Computation of triangle sides.

No.	Stations.	No.	Observed angles.	SECONDS OF— Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
							mc	± 7 9
	Measured Epping Base				2..1		8715.942	3.9403143 4
	Burke	3	° ′ ″ 39 19 35.850	″ + .080	″ 35.930	″ .079	″ 35.851	0.1980886 0
1	West Base	2	89 03 11.750	— .422	11.328	.080	11.248	9.9999406 9
	East Base	1	51 37 12.900	+ .080	12.980	.079	12.901	9.8942678 4
					3..1			4.1383436 4
					3..2			4.0326707 8
					2..1			3.9403143 4
	Tunk	4	16 04 34.010	+ .906	34.916	.068	34.848	0.5576488 3
2	West Base	2	138 04 57.080	— .122	56.958	.067	56.891	9.8248156 3
	East Base	1	25 50 29.840	—1.511	28.329	.068	28.261	9.6393650 8
					4..1			4.3227788 0
					4..2			4.1373282 4
					2..3			4.0326707 8
	T unk	4	50 45 11.850	— .039	11.811	.094	11.717	0.1110186 3
3	West Base	2	49 01 45.330	+ .300	45.630	.094	45.536	9.8779729 3
	Burke	3	80 13 02.640	+ .203	02.843	.095	02.747	9.9936388 4
					4..3			4.0216623 3
					4..2			4.1373282 4
					1..3			4.1383436 4
	Tunk	4	34 40 37.840	— .945	36.895	.106	36.789	0.2449275 7
4	East Base	1	25 46 43.060	+1.591	44.651	.106	44.545	9.6383911 2
	Burke	3	119 32 38.490	+ .283	38.773	.107	38.666	9.9395076 0
					4..3			4.0216623 3
					4..1			4.3227788 0

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF— Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
			° ′ ″	″	″	″	″	
					2..1			3.9403143 4
	Pigeon	5	19 00 56.560	—1.180	55.380	.178	55.202	0.4870206 8
5	West Base	2	64 55 08.300	— .951	09.251	.178	09.073	9.9569895 5
	East Base	1	96 03 55.500	+ .402	55.902	.177	55.725	9.9975619 0
					5..1			4.3843245 7
					5..2			4.4248969 2
					3..1			4.1383436 4
	Pigeon	5	33 44 59.030	— .174	58.856	.197	58.659	0 2552652 6
6	Burke	3	101 48 19.820	—1.005	18.815	.197	18.617	9.9907156 7
	East Base	1	44 26 42.600	+ .322	42.922	.198	42.724	9.8452587 1
					5..1			4.3843245 6
					5..3			4.2388476 1
					4..1			4.3227788 0
	Pigeon	5	49 08 34.310	+ .629	34.939	.405	34.534	0.1212807 5
7	Tunk	4	60 37 58.620	+ .684	58.704	.405	58.299	9.9402650 1
	East Base	1	70 13 25.660	+1.913	27.573	.406	27.167	9.9736006 2
					5..1			4.3843245 7
					5..4			4.4176601 8
					3..2			4.0326707 8
	Pigeon	5	14 44 02.470	+1.006	03.476	.099	03.377	0.5945913 6
8	Burke	3	141 07 55.670	— .925	54.745	.100	54.645	9.7976347 7
	West Base	2	24 08 03.450	—1.373	02.077	.099	01.978	9.6115854 7
					5..2			4.4248969 1
					5..3			4.2388476 1
					4..2			4.1373282 4
	Pigeon	5	30 07 37.750	+1.809	39.559	.295	39.264	0.2993594 2
9	Tunk	4	76 42 32.630	+ .990	33.620	.296	33.324	9.9882092 5
	West Base	2	73 09 48.780	—1.073	47.707	.295	47.412	9.9809725 2
					5..2			4.4248969 1
					5..4			4.4176601 8
					4..3			4.0216623 3
	Pigeon	5	15 23 35.280	+ .803	36.083	.101	35.982	0.5760273 3
10	Tunk	4	25 57 20.780	+1.029	21.809	.102	21.707	9.6411579 5
	Burke	3	138 39 01.690	+ .723	02.413	.102	02.311	9.8199705 2
					5..3			4.2388476 1
					5..4			4.4176601 8
					1..2			3.9403143 4
	Humpback	6	9 55 37.650	— .051	37.599	.105	37.494	0.7634760 7
11	East Base	1	27 41 01.010	+ .320	01.330	.106	01.223	9.6670696 0
	West Base	2	142 23 21.940	— .551	21.389	.106	21.283	9.7855390 1
					6..2			4.3708600 2
					6..1			4.4893294 2
					1..3			4.1383436 4
	Humpback	6	25 31 14.879	— .220	14.659	.352	14.307	0.3656877 9
12	East Base	1	79 18 13.910	+ .400	14.310	.352	13.957	9.9923879 7
	Burke	3	75 10 31.480	+ .609	32.089	.353	31.736	9.9852880 0
					6..3			4.4964193 9
					6..1			4.4893294 3
					1..4			4.3227788 0
	Humpback	6	42 39 01.097	— .042	01.055	.441	00.614	0.1690777 1
13	East Base	1	53 31 30.850	—1.192	29.658	.441	29.217	9.9053176 6
	Tunk	4	83 49 30.540	+ .070	30.610	.441	30.169	9.9974729 2
					6..4			4.3971741 7
					6..1			4.4893294 3
					1..5			4.3843245 6
	Humpback	6	24 26 46.698	— .358	46.340	.525	45.815	0.3831713 2
14	East Base	1	123 44 56.510	+ .721	57.231	.525	56.706	9.9198510 2
	Pigeon	5	31 48 17.670	+ .335	18.005	.526	17.479	9.7218335 4
					6..5			4.6873469 0
					6..1			4.4893294 2

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF— Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
			° ′ ″	″	″	″	″	
					2..3			4.0326707 8
	Humpback	6	15 35 37.229	—.169	37.060	.167	36.893	0.5705514 8
15	West Base	2	128 33 26.310	+.973	27.283	.168	27.115	8.8931971 3
	Burke	3	35 50 55.630	+.529	56.159	.167	55.992	9.7676377 7
					6..3			4.4964193 9
					6..2			4.3708600 2
					2..4			4.1373282 4
	Humpback	6	32 43 23.447	+.009	23.456	.268	23.188	0.2671403 0
16	West Base	2	79 31 40.980	+.674	41.654	.268	41.386	9.9927056 3
	Tunk	4	67 44 56.530	—.836	55.694	.268	55.426	9.9663914 9
					6..4			4.3971741 7
					6..2			4.3708600 3
					2..5			4.4248969 1
	Humpback	6	14 31 09.048	—.308	08.740	.242	08.498	0.6008430 7
17	West Base	2	152 41 29.760	—.399	29.361	.242	29.118	9.6616069 3
	Pigeon	5	12 47 21.110	+1.515	22.625	.241	22.384	9.3451200 6
					6..5			4.6873469 1
					6..2			4.3708600 4
					3..4			4.0216623 3
	Humpback	6	17 07 46.218	+.178	46.396	.195	46.201	0.5308669 2
18	Burke	3	44 22 07.010	—.326	06.684	.195	06.489	9.8446449 3
	Tunk	4	118 30 08.380	—.875	07.505	.195	07.310	9.9438901 5
					6..4			4.3971741 8
					6..3			4.4964194 0
					5..3			4.2388476 1
	Humpback	6	1 04 28.181	+.138	28.319	.024	28.2952	1.7269369 8
19	Pigeon	5	1 56 41.360	—.509	40.851	.024	40.8266	8.5306408 0
	Burke	3	176 58 51.300	—.397	50.903	.025	50.8782	8.7215683 1
					6..3			4.4964193 9
					6..5			4.6873469 0
					5..4			4.4176601 8
	Humpback	6	18 12 14.399	+.316	14.715	.321	14.394	0.5052872 9
20	Pigeon	5	17 20 16.640	+.293	16.933	.320	16.613	9.4742267 1
	Tunk	4	144 27 29.160	+.154	29.314	.321	28.993	9.7643994 4
					6..4			4.3971741 8
					6..5			4.6873469 1
					3..1			4.1383436 4
	Mt. Desert	7	5 26 36.898	+.337	37.235	.129	37.106	1.0228867 7
21	Burke	3	160 58 42.360	—1.051	41.309	.129	41.180	9.5131235 9
	East Base	1	13 34 42.400	—.557	41.843	.129	41.714	9.3706485 1
					7..1			4.6743540 0
					7..3			4.5318789 2
					4..1			4.3227788 0
	Mt. Desert	7	23 17 01.756	—.268	01.488	.532	00.956	0.4030923 3
22	Tunk	4	117 21 33.910	—.294	33.616	.533	33.083	9.9484828 7
	East Base	1	39 21 25.460	+1.034	26.494	.533	25.961	9.8021942 3
					7..1			4.6743540 0
					7..4			4.5280653 6
					1..5			4.3843245 6
	Mt. Desert	7	25 10 22.487	+.451	22.938	.496	22.442	0.3712522 5
23	East Base	1	30 52 00.200	+.878	01.078	.496	00.582	9.7101549 4
	Pigeon	5	123 57 37.170	+.303	37.473	.497	36.976	9.9187771 8
					7..5			4.4657317 5
					7..1			4.6743540 0
					6..1			4.4893294 3
	Mt. Desert	7	32 16 26.482	—.062	26.420	1.231	25.189	0.2724882 2
24	Humpback	6	54 50 40.476	+.643	41.119	1.231	39.888	9.9125363 6
	East Base	1	92 52 56.310	—.157	56.153	1.230	54.923	9.9994503 9
					7..1			4.6743540 0
					7..6			4.7612680 3

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	Seconds of— Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
			° ′ ″	″	″	″	″	
					4..3			4.0216623 3
	Mt. Desert	7	17 50 24.858	−.605	24.253	.297	23.956	0.5137683 1
25	Tunk	4	82 40 56.070	+.651	56.721	.297	56.424	9.9964482 9
	Burke	3	79 28 39.150	+.768	39.918	.298	39.620	9.9926347 2
					7..3			4.5318789 3
					7..4			4.5280653 6
					3..5			4.2388476 1
	Mt. Desert	7	30 36 59.385	+.788	60.173	.428	59.745	0.2930342 5
26	Burke	3	59 10 22.540	−.045	22.495	.428	22.067	9.9338499 0
	Pigeon	5	90 12 38.140	+.476	38.616	.428	38.188	9.9999970 7
					7..5			4.4657317 5
					7..3			4.5318789 2
					6..3			4.4964193 9
	Mt. Desert	7	26 49 49.584	−.399	49.185	.749	48.436	0.3454897 1
27	Humpback	6	29 19 25.597	+.864	26.461	.750	25.711	9.6899698 2
	Burke	3	123 50 46.160	+.442	46.602	.749	45.853	9.9193589 3
					7..3			4.5318789 2
					7..6			4.7612680 3
					4..5			4.4176601 8
	Mt. Desert	7	48 27 24.243	+.183	24.426	.624	23.802	0.1258350 5
28	Tunk	4	56 43 35.290	−.378	34.912	.624	34.288	9.9222365 3
	Pigeon	5	74 49 02.860	−.327	02.533	.623	01.910	9.9845701 3
					7..5			4.4657317 6
					7..4			4.5280653 6
					6..4			4.3971741 7
	Mt. Desert	7	8 59 24.726	+.206	24.932	.257	24.675	0.8061374 1
29	Humpback	6	12 11 39.379	+.686	40.065	.257	39.808	9.3247537 7
	Tunk	4	158 48 55.550	+.225	55.775	.258	55.517	9.5579564 4
					7..4			4.5280653 6
					7..6			4.7612680 3
					6..5			4.6873469 1
	Mt. Desert	7	57 26 48.969	+.389	49.358	1.202	48.156	0.0742284 0
30	Humpback	6	30 23 53.778	+1.002	54.780	1.202	53.578	9.7041564 5
	Pigeon	5	92 09 19.500	−.033	19.467	1.201	18.266	9.9996927 2
					7..5			4.4657317 6
					7..6			4.7612680 3
					3..1			4.1383436 4
	Howard	8	11 28 06.015	+1.171	07.186	.271	06.915	0.7015166 5
31	Burke	3	30 19 45.160	−1.500	43.660	.271	43.389	9.7032572 6
	East Base	1	138 12 09.940	+.026	09.966	.270	09.696	9.8237984 8
					8..1			4.5431175 5
					8..3			4.6636587 6
					5..1			4.3843245 6
	Howard	8	33 30 40.141	+.204	40.345	.714	39.631	0.2579844 6
32	Pigeon	5	52 43 54.520	+.233	54.753	.714	54.039	9.9008085 2
	East Base	1	93 45 27.340	−.297	27.043	.713	26.330	9.9990655 1
					8..1			4.5431175 4
					8..5			4.6413745 3
					1..6			4.4893294 3
	Howard	8	17 33 01.364	+1.028	02.392	.555	01.837	0.5206457 8
33	East Base	1	142 29 36.150	−.424	35.726	.554	35.172	9.7845152 5
	Humpback	6	19 57 24.016	−.470	23.546	.555	22.991	9.5331423 3
					8..6			4.7944904 5
					8..1			4.5431175 3
					7..1			4.6743540 0
	Howard	8	32 11 14.197	+.316	14.513	1.148	13.365	0.2735295 8
34	Mt. Desert	7	23 11 19.990	+.818	20.808	1.148	19.660	9.5952339 6
	East Base	1	124 37 27.540	+.582	28.122	1.147	26.975	9.9153454 0
					8..1			4.5431175 4
					8..7			4.8632289 8

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	Corr. (Seconds of—)	Spherical angles. (Seconds of—)	Spherical excess. (Seconds of—)	Plane angles and distances. (Seconds of—)	Logarithms.
			° ′ ″	″	″	″	″	
					5..3			4.2388476 1
	Howard	8	22 02 34.126	— .968	33.158	.640	32.518	0.4256306 0
35	Pigeon	5	86 28 53.550	+ .059	53.609	.641	52.968	9.9991805 4
	Burke	3	71 28 34.660	+ .494	35.154	.640	34.514	9.9768963 2
					8..3			4.6636587 5
					8..5			4.6413745 3
					3..6			4.4964193 9
	Howard	8	29 01 07.379	+2.199	09.578	1.177	08.401	0.3141690 5
36	Burke	3	105 30 16.640	— .891	15.749	1.178	14.571	9.9839020 1
	Humpback	6	45 28 38.895	— .690	38.205	1.177	37.028	9.8530703 1
					8..6			4.7944904 5
					8..3			4.6636587 6
					7..3			4.5318789 2
	Howard	8	20 43 08.182	— .856	07.326	1.006	06.320	0.4512721 3
37	Mt. Desert	7	28 37 56.888	+1.155	58.043	1.006	57.037	9.6805077 1
	Burke	3	130 38 57.200	+ .449	57.649	1.006	56.643	9.8800779 3
					8..3			4.6636587 6
					8..7			4.8632289 8
					5..6			4.6873469 1
	Howard	8	51 03 41.505	+1.231	42.736	1.794	40.942	0.1091211 1
38	Pigeon	5	84 32 12.190	+ .569	12.759	1.793	10.966	9.9980224 4
	Humpback	6	44 24 10.714	— .828	09.886	1.794	08.092	9.8449065 2
					8..6			4.7944904 6
					8..5			4.6413745 3
					5..7			4.4657317 6
	Howard	8	1 19 25.944	— .112	25.832	.062	25.7699	1.6363307 0
39	Pigeon	5	176 41 31.690	+ .535	32.225	.063	32.1620	8.7611665 2
	Mt. Desert	7	1 59 02.497	— .367	02.130	.062	02.0681	8.5393120 7
					8..7			4.8632289 8
					8..5			4.6413745 3
					7..6			4.7612680 3
	Howard	8	49 44 15.561	+1.344	16.905	2.933	13.972	0.1174252 2
40	Mt. Desert	7	55 27 46.472	+ .756	47.228	2.933	44.295	9.9157972 0
	Humpback	6	74 48 04.492	+ .174	04.666	2.933	01.733	9.9845357 3
					8..6			4.7944904 5
					8..7			4.8632289 8
					3..6			4.4964193 9
	Cooper	9	32 00 62.260	—1.165	61.095	1.389	59.706	0.2755891 8
41	Burke	3	62 44 36.700	+1.178	37.878	1.389	36.489	9.9488846 3
	Humpback	6	85 14 25.280	— .085	25.195	1.390	23.805	9.9984995 1
					9..6			4.7208932 0
					9..3			4.7705080 8
					7..3			4.5318789 2
	Cooper	9	2 24 39.965	— .063	39.902	.194	39.7075	1.3760482 2
42	Mt. Desert	7	4 10 44.694	+ .467	45.161	.195	44.9665	8.8625809 3
	Burke	3	173 24 37.140	—1.620	35.520	.194	35.3260	9.0598171 0
					9..3			4.7705080 8
					9..7			4.9677442 4
					8..3			4.6636587 6
	Cooper	9	51 15 31.369	+ .578	31.947	1.559	30.388	0.1079183 8
43	Howard	8	85 58 53.870	+ .990	54.860	1.560	53.300	9.9989309 5
	Burke	3	42 45 39.940	—2.069	37.871	1.559	36.312	9.8318250 1
					9..3			4.7705080 8
					9..8			4.6034021 4
					7..6			4.7612680 3
	Cooper	9	34 25 42.225	—1.228	40.997	2.333	38.664	0.2476736 8
44	Mt. Desert	7	31 00 34.278	+ .069	34.347	2.333	32.014	9.7119515 0
	Humpback	6	114 33 50.877	+ .779	51.656	2.334	49.322	9.9588025 4
					9..6			4.7208932 1
					9..7			4.9677442 5

Computation of triangle sides—Continued.

No.	Stations.	No.	Observed angles.	SECONDS OF— Corr.	Spherical angles.	Spherical excess.	Plane angles and distances.	Logarithms.
			° ′ ″	″	″	″	″	
					8..6	....	....	4.7944904 5
	Cooper	9	83 16 33.629	— .587	33.042	1.772	31.270	0.0029981 1
45	Howard	8	56 57 46.491	—1.209	45.282	1.771	43.511	9.9234046 4
	Humpback	6	39 45 46.385	+ .605	46.990	1.771	45.219	9.8059135 7
					9..6	....	....	4.7208932 0
					9..8	....	....	4.6034021 4
					8..7	....	....	4.8632280 8
	Cooper	9	48 50 51.404	+ .641	52.045	2.371	49.674	0.1232301 2
46	Howard	8	106 41 62.052	+ .134	62.186	2.371	59.815	9.9812851 5
	Mt. Desert	7	24 27 12.194	+ .688	12.882	2.371	10.511	9.6169430 4
					9..7	....	....	4.9677442 5
					9..8	....	....	4.6034021 4

(16.) *Resulting distance from Mt. Desert to Humpback.*

The logarithmic difference between the base and the primary triangle side, Mt. Desert–Humpback, is, accordingly, 0.8209536 9. It may also be stated that a seven-place computation, using the principal corrections only, as given in art. 13, gave for the above difference 0.8209537.

If we use the ten-place computation, we find the logarithmic length of the side, independently, from four triangles, as follows:

	4.7612680	279	
		300	
		318	
		310	
Mean,	4.7612680	302	number = 57712.253 m
log. base,	3.9403143	416	
log. difference,	0.8209536	886	

The consideration of the probable error of the derived side, Mt. Desert–Humpback, will be reserved for a subsequent communication.

(17) *Connexion of the azimuth mark with the adjusted directions.*

The direction of the azimuth mark requires a small change, due to the adjustment of the geometrical figure of the triangulation, so as to make it dependent upon all the directions at each station. It was done as follows: The angular difference of the mark and each direction, as resulting from the abstract of results given in art. 5, was again applied to the adjusted angles, (the sign being reversed,) each direction furnishing a result of the reading of the azimuth mark; the indiscriminate mean, without regard to weights, was taken for the final value, and inserted in the preceding table of results, art. 14.

Thus for Humpback we have (omitting here degrees and minutes:)

	Difference.	Azimuth mark.
	″	″
Cooper	+ 40.230	40.230
Howard	— 06.155	.835
East Base	— 30.171	.365
West Base	— 07.821	.314
Pigeon	— 16.869	.007
Burke	— 45.050	.145
Tunk	— 31.268	.323
Desert	— 10.647	.009
	Mean	40.403 ± 0.″081

The former probable error (art. 5) was ± 0.″163, which, combined with ± 0.″081, gives the final probable error .... ± 0.″182
Similarly for Mt. Desert .... ± 0.″134
Similarly for Howard .... ± 0.″221
Similarly for Cooper .... ± 0.″229

Considering the change in the initial direction at each station, the change produced by the above process amounts only to a few hundredths of a second.

The adjustment of the adjoining triangulation will yet exert a small influence upon the azimuthal directions of Mt. Desert and Humpback, also upon Howard and Cooper.

APPENDIX No. 15.

LIST OF GEOGRAPHICAL POSITIONS DETERMINED BY THE UNITED STATES COAST SURVEY, AND CONTINUED FROM REPORTS OF 1851, 1853, 1855, 1857, AND 1859.

The present list is a continuation of that published in the annual reports for 1851, 1853, 1855, 1857, and 1859, and contains the geographical positions of points determined astronomically and trigonometrically since the date of the former reports, with the repetition of a few points previously published, for convenience of reference. The present publication, however, is limited to positions on the northern and western coasts. Those on the southern coast are also prepared in manuscript, but their publication at present is not deemed expedient. The following explanations will give all the information required for the use of the tables:

For the purposes of the survey the coast is divided into eleven sections, in all of which the work is carried on simultaneously. The survey being in different stages of progress in the several sections, and new results being added from year to year to those here given, the same divisions have been adopted in the publication.

The several sections are defined as follows:
Section I. From Passamaquoddy bay to Point Judith.
Section II. From Point Judith to Cape Henlopen.
Section III. From Cape Henlopen to Cape Henry.
Section IV. From Cape Henry to Cape Fear.
Section V. From Cape Fear to St. Mary's river.
Section VI. From St. Mary's river to St. Joseph's bay.
Section VII. From St. Joseph's bay to Mobile bay.
Section VIII. From Mobile bay to Vermilion bay.
Section IX. From Vermilion bay to the Rio Grande.
Section X. Coast of California, San Diego bay, to 42d parallel.
Section XI. Coast of Oregon and Washington Territory, 42d to 49th parallel.

The tables give the latitudes and longitudes of the trigonometrical points in each section, and their relative azimuths or bearings and distances. The manner in which these data have been obtained may be briefly explained here.

In each section a base line of from five to ten miles is measured with all possible accuracy. A series of triangles, deriving the length of their sides from this base, is then established along the coast by the measurement of the angles between the intervisible stations. In this primary series the triangles are made as large as the nature of the country will permit, because the liability to error increases with the number of triangles.

On the bases furnished by the sides of the primary triangles a secondary triangulation is next established, extending along the coast and over the smaller bays and sounds, and determining a large number of points at distances a few miles apart for the use of the topographical and hydrographical surveys.

The distances between the points thus determined, as given in the tables, are liable to an average error of about one foot in six miles, until a final adjustment between the base lines shall have been made.

In some parts of the survey the base lines for the primary triangulations have not yet been measured, or the connexion between the secondary and primary triangulation has not yet been made; in which cases the distances depend on preliminary base lines, measured with great care, and they are liable to an average error of one foot in three miles.

As, on the completion of the primary or main triangulation in each section, the several series form one connected chain, the different bases afford verifications of each other and of the triangulation connecting them. The first four sections are thus connected; the last section and part of the fifth, however, only in a preliminary way.

Observations for latitude and azimuth are made at a number of stations of the primary triangulation in each section. The differences of latitude, longitude, and azimuth between these and other stations are then computed, under the supposition that the earth is a spheroid of revolution of the following dimensions, which are those determined by Bessel from the reliable measurements made at the time, viz:

Equatorial radius = 6377397.16 metres.
Polar radius = 6356078.96 metres.
Eccentricity = 0.08169683.

It has been found that the differences of latitude and longitude, as computed in this manner, from the distance and azimuth between two stations, and which are called geodetic, differ from those which are obtained by astronomical observations at the several stations by quantities which are greater than the errors of the observations. Such disagreements are due to local irregularities in the figure and density of the earth, and the error resulting from them in the determinations of latitude and of the meridian plane is designated as station error. It amounts, according to the results obtained at present, to between one and four seconds of arc in the eastern section of the survey, and to about one second and a half in the sections south of the Delaware.

In order to eliminate the influence of station errors on the general result, observations are made at a number of stations, the results are referred to a central station by means of the geodetic differences, and the mean of all is used for the computation of the positions given in the tables. The geographical positions must therefore be considered as liable to future changes from the accumulation of new observations and from the final discussion of all the results obtained.

The *differences of longitude* are obtained, as has been stated, by computation from the distances, latitudes, and azimuths of the triangulation. In adding up the differences from station to station, an accumulation of the incidental errors is probable. They are checked, however, by differences of longitude, determined by means of the electro-magnetic telegraph in every section where the introduction of the latter makes it practicable.

Seaton station, in Washington city, has been selected as the centre for the telegraphic differences of longitude. The sections at present connected by telegraph are Sections I, II, III, IV, V, VII, and VIII. The first three being also connected by primary triangulation, the check on the geodetic differences of longitude is here obtained, and the agreement is very close. The longitudes from Greenwich in the first five sections depend directly, and in other sections indirectly, upon that of Cambridge observatory, as determined by chronometric differences between Liverpool and Cambridge, and by occultations, eclipses, and moon culminations observed at various observatories in the United States, and referred to Cambridge by means of telegraphic differences.

The longitude of Cambridge, Harvard observatory, as adopted in former reports, (since 1851,) viz: *4h. 44m. 29.5s.*, or 71° 07′ 22.50″, is, for uniformity's sake, still retained. From later discussions it would seem to bear an increase of about three-quarters of a second of time.

The longitude in Section X is reckoned from Greenwich. It depends on moon culminations observed at San Diego, Point Conception, Point Pinos, Presidio, Telegraph Hill, Port Orford, Cape Disappointment, and Cape Flattery, compared with corresponding observations at Greenwich and American observatories, and on chronometric differences between the same and other stations.

In Section X the longitude of Presidio observatory, San Francisco, has been adopted—122° 26′ 15.0″.

EXPLANATION OF THE TABLES.

The first column on the left contains the name of the several stations or triangulation points. Their general locality is indicated by the heading at the top of the page, by means of which they may be readily found on the sketches accompanying the tables. Sub-headings in the first column indicate the locality more minutely where it is practicable.

The stations are generally either prominent objects of permanence, such as spires, light-houses, beacons, &c., or they are points on prominent hills, capes, and points of land, where signals have been erected for the purposes of the survey, and which are marked on the ground. In a small number of cases in the first three sections, but much more frequently in the southern sections, where settlements on the coast are sparse and few permanent objects are to be found, the stations have no other distinguishing mark than the signal erected on the spot, and, after its decay, the mark left in the ground to designate the station point. The latter generally consists of posts or stones set around the point, while the centre of the station is designated by an earthen cone or glass bottle buried under the surface of the ground, and marked on the top by a stone or post. Where the station is on a rock, a copper bolt, or hole filled with lead or sulphur, will be found to designate the exact spot.

The sketches showing the configuration of the land, as well as the relative positions of the stations, no great difficulty will be experienced in finding the latter when desired for local surveys or reference. In any case where minute descriptions of particular points are required, they can be had by application addressed to the Coast Survey office.

The second and third columns contain the latitudes and longitudes of the stations named.

The fourth column contains the azimuth of the line joining the station named in the first column with that named in the fifth; that is to say, the angle which that line makes with the meridian of the former station, reckoned from south around by west through the whole circle.

The sixth column gives the back azimuth of the same line, or the angle which it makes with the meridian of the latter station, reckoned as before; the difference between the azimuths in the fourth and those in the sixth column being 180°, less the inclination of the meridians at the two stations.

The seventh, eighth, and ninth columns give the distances in metres, yards, and miles between the stations named in the first and fifth columns. The relation of the metre to the yard used in obtaining these results is: 1 metre=1.0935696 yards, or 39.368505 United States standard inches.

For each station the azimuths and distances to two other stations are given. In every case the lines so given have actually been observed.

In each section the stations of the primary triangulation are distinguished by being printed in SMALL CAPITALS.

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
COOPER	44 59 12.33	67 27 39.74	40 44 03	Mount Desert	220 12 00	92841.0	101528.1	57.69
			75 09 44	Humpback	254 42 28	52588.2	57508.9	32.68
HOWARD	44 37 45.31	67 23 22.85	114 58 26	Humpback	294 28 15	62290.9	68129.3	38.71
			65 14 09	Mount Desert	244 39 12	72983.5	79812.5	45.35
GRAND MANAN	44 44 52.31	66 49 30.40	73 47 18	Howard	253 23 29	46648.6	51013.5	28.98
			118 04 11	Cooper	297 37 16	56830.5	62148.1	35.31
CHAMCOOK	45 07 29.13	67 04 38.96	334 28 27	Grand Manan	154 39 09	46375.6	50714.9	28.81
			63 13 19	Cooper	242 57 02	33877.9	37047.8	21.05
Prince Regent's Redoubt	44 55 10.25	67 00 17.15	101 53 11	Cooper	281 33 50	36767.9	40208.2	22.84
			165 55 10	Chamcook	345 52 05	23515.9	25716.3	14.61
Trescott Rock	44 45 31.02	67 06 08.28	57 50 43	Howard	237 38 36	26932.2	29452.2	16.74
			203 17 49	Prince Regent's Redoubt	23 21 57	19470.2	21292.0	12.09
Arcus	44 54 11.16	67 11 11.28	262 41 25	Prince Regent's Redoubt	82 49 07	14462.6	15815.8	8.99
			337 27 18	Trescott Rock	157 30 51	17378.6	19004.7	10.80
Porcupine	44 49 19.87	67 00 58.35	123 48 42	Arcus	303 41 30	16182.2	17696.4	10.05
			43 59 31	Trescott Rock	223 55 52	9813.1	10731.3	6.10
Perry Pigeon	44 57 05.33	67 03 13.91	348 17 22	Porcupine	168 18 58	14671.5	16044.3	9.12
			312 29 30	Prince Regent's Redoubt	132 31 35	5256.8	5748.6	3.27
Hannah	44 58 04.02	66 57 31.30	34 08 46	Prince Regent's Redoubt	214 06 48	6479.6	7085.9	4.03
			76 28 06	Perry Pigeon	256 24 04	7723.5	8446.2	4.80
Hannabury	44 56 17.75	66 54 48.68	97 36 15	Perry Pigeon	277 30 18	11171.9	12217.3	6.94
			73 53 57	Prince Regent's Redoubt	253 50 05	7497.6	8199.1	4.66
Friar's Head	44 52 33.65	66 57 57.83	140 27 08	Perry Pigeon	320 23 25	10880.0	11898.0	6.76
			147 42 30	Prince Regent's Redoubt	327 40 52	5719.0	6254.1	3.55
Foster	44 55 29.27	67 06 46.68	326 07 26	Porcupine	146 11 32	13727.7	15012.2	8.53
			237 32 18	Perry Pigeon	57 34 48	5527.0	6044.2	3.43
Quoddy	44 48 50.73	66 57 25.74	61 49 48	Trescott Rock	241 43 40	13035.2	14254.9	8.10
			118 42 11	Arcus	298 32 29	20646.0	22577.9	12.83
Bishop	44 47 55.77	66 46 26.76	96 44 56	Quoddy	276 37 12	14578.8	15942.9	9.06
			142 13 37	Hannah	322 05 48	23771.8	25996.2	14.77
Wolf	44 56 11.59	66 43 42.39	53 06 02	Quoddy	232 56 21	22619.6	24736.1	14.06
			100 53 39	Hannah	280 43 53	18495.3	20225.9	11.49
White Horse	44 59 30.43	66 51 58.28	32 07 50	Hannabury	212 05 50	7022.4	7679.5	4.36
			69 56 46	Hannah	249 52 51	7767.1	8493.9	4.83
Denboe	44 52 51.89	67 05 20.17	237 15 05	Prince Regent's Redoubt	57 18 39	7901.0	8640.3	4.91
			107 39 14	Arcus	287 35 06	8082.6	8838.8	5.02
Raccoon	44 54 42.59	66 56 11.66	30 21 03	Friar's Head	210 19 48	4611.4	5042.9	2.87
			211 46 12	Hannabury	31 47 11	3455.2	3778.5	2.15
Treat	44 52 43.15	66 59 03.20	160 20 41	Prince Regent's Redoubt	340 19 49	4821.7	5272.9	3.00
			281 32 42	Friar's Head	101 33 28	1464.1	1601.1	0.91
Indian Island	44 56 13.78	66 57 48.31	268 12 02	Hannabury	88 14 09	3940.0	4308.7	2.45
			59 00 57	Prince Regent's Redoubt	238 59 12	3807.4	4163.7	2.37
Marvel	44 55 13.05	66 57 50.92	1 45 56	Friar's Head	181 45 51	4922.5	5383.1	3.06
			88 28 08	Prince Regent's Redoubt	268 26 25	3207.9	3508.0	1.99
East Quoddy Light	44 57 27.91	66 53 39.56	102 23 50	Hannah	282 21 06	5199.2	5685.7	3.23
			280 08 37	Wolf	100 15 39	13299.5	14543.9	8.26
White Island Ledge	44 58 54.23	66 53 47.01	290 41 15	Wolf	110 48 22	14168.9	15494.6	8.80
			72 30 37	Hannah	252 27 59	5153.2	5635.4	3.20
Bar Island	44 58 21.41	66 56 28.97	330 03 10	Hannabury	150 04 21	4404.6	4816.7	2.74
			23 49 24	Indian Island	203 48 28	4306.1	4709.0	2.68
Hybernia Cove	44 57 23.83	66 57 29.16	241 38 06	White Horse	61 42 00	8235.1	9005.7	5.12
			300 05 25	Hannabury	120 07 18	4066.3	4446.8	2.53
Indian Point	44 50 02.34	66 56 50.05	19 32 12	Quoddy	199 31 47	2345.3	2564.7	1.46
			76 30 35	Porcupine	256 27 40	5609.1	6134.0	3.49
Owen	44 49 49.88	66 55 17.59	82 58 53	Porcupine	262 54 53	7541.5	8247.1	4.69
			286 45 19	Bishop	106 51 33	12182.5	13322.4	7.57
Comstock, (2)	44 53 11.16	67 00 50.94	330 42 42	Quoddy	150 45 07	9214.6	10076.8	5.73
			156 33 59	Perry Pigeon	336 32 18	7878.5	8615.7	4.90
Roger	44 52 09.70	66 59 56.90	254 11 49	Friar's Head	74 13 13	2715.4	2969.5	1.69
			175 26 54	Prince Regent's Redoubt	355 26 40	5590.7	6113.8	3.47

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
West Quoddy Light	44 48 53.71	66 56 40.96	231 34 46	Wolf	51 43 55	21785.4	23823.9	13.54
			277 29 15	Bishop	97 36 28	13613.8	14887.7	8.46
Herring Cove, flag in tree	44 52 36.46	66 54 33.91	177 15 43	Hannabury	357 15 32	6836.2	7475.9	4.25
			28 26 36	Quoddy	208 24 35	7920.5	8661.6	4.92
Beech, flag in tree	44 56 59.05	66 58 39.57	216 42 44	Hannah	36 43 32	2502.1	2736.2	1.55
			91 52 24	Perry Pigeon	271 49 10	6015.8	6578.7	3.74
North Head	45 01 23.37	66 56 33.10	11 42 39	Hannah	191 41 58	6284.1	6872.1	3.90
			346 21 30	Hannabury	166 22 44	9707.0	10615.3	6.03
Anley	45 03 04.22	66 52 20.70	60 37 08	North Head	240 34 09	6340.4	6933.6	3.94
			355 45 03	White Horse	175 45 19	6616.4	7235.5	4.11
Navy	45 03 16.70	67 02 17.82	294 50 24	North Head	114 54 28	8315.8	9093.9	5.17
			158 24 23	Chamcook	338 22 43	8380.6	9164.8	5.21
Shortland	45 05 25.50	67 08 50.19	235 10 43	Chamcook	55 13 41	6687.0	7312.7	4.15
			334 28 18	Perry Pigeon	154 32 16	17104.0	18704.4	10.63
Pembroke	44·57 44.71	67 11 44.08	287 30 05	Prince Regent's Redoubt	107 38 10	15795.4	17273.4	9.81
			302 38 33	Foster	122 42 03	7744.5	8469.1	4.81
Yellow House, chimney	44 55 38.50	67 07 06.05	303 49 46	Foster	123 50 00	511.5	559.3	0.32
			335 41 02	Denboe	155 42 17	5642.8	6170.8	3.51
Kendall	44 55 57.10	67 00 33.85	84 02 26	Foster	263 58 02	8220.0	8989.1	5.11
			345 46 58	Prince Regent's Redoubt	165 47 10	1491.8	1631.4	0.93
Eastport, Unitarian church	44 54 10.11	66 58 58.51	103 25 58	Foster	283 20 27	10555.0	11542.7	6.56
			335 53 58	Friar's Head	155 54 41	3262.0	3567.2	2.03
Esty	44 53 31.97	66 59 30.01	311 39 43	Friar's Head	131 40 48	2707.6	2960.9	1.68
			143 18 59	Perry Pigeon	323 16 21	8214.4	8983.0	5.10
Red Island, flag in tree	44 54 44.14	67 04 34.83	115 43 33	Foster	295 42 00	3209.0	3509.2	1.99
			261 51 07	Prince Regent's Redoubt	81 54 09	5708.4	6242.5	3.55
Gould's House	44 54 10.75	67 03 11.02	117 09 16	Foster	297 06 44	5314.7	5812.0	3.30
			179 19 33	Perry Pigeon	359 19 31	5389.1	5893.4	3.35
Seward's Neck, tall pine	44 53 23.14	67 02 36.54	173 11 17	Perry Pigeon	353 10 51	6907.0	7553.3	4.29
			222 45 07	Prince Regent's Redoubt	42 46 45	4503.2	4924.6	2.80
Tall Pine	44 51 06.45	67 03 39.26	153 08 12	Foster	333 06 00	9095.0	9946.0	5.65
			250 12 48	Friar's Head	70 16 49	7963.0	8708.1	4.95
Bushy-top Tree	44 50 19.53	67 03 38.12	156 37 17	Foster	336 35 04	10416.2	11390.9	6.47
			154 31 41	Denboe	334 30 29	5210.1	5697.6	3.24
Little	44 51 09.06	67 09 14.83	287 07 41	Porcupine	107 13 31	11412.4	12480.2	7.09
			155 33 39	Arcus	335 32 17	6174.2	6751.9	3.84
North end of Spruce Island	44 58 29.42	66 53 55.79	80 35 39	Hannah	260 33 07	4786.4	5234.3	2.97
			233 46 52	White Horse	53 48 15	3188.8	3487.2	1.98
Cape Lepreau Light	45 03 29.15	66 27 10.62	41 27 33	Bishop	221 13 57	38374.7	41965.4	23.84
			76 02 51	Hannah	255 41 23	41106.3	44952.6	25.54
Chimney of house on Sand Island	44 58 20.98	66 54 28.66	82 33 48	Hannah	262 31 39	4036.0	4413.7	2.51
			236 55 10	White Horse	56 56 56	3930.1	4297.8	2.44
South end of Spruce Island	44 58 10.00	66 54 16.58	87 32 42	Hannah	267 30 24	4270.8	4670.4	2.65
			11 28 49	Hannabury	191 28 26	3535.4	3866.2	2.20
East end of Casco Island	44 57 23.27	66 55 21.56	55 56 06	Indian Island	235 54 22	3884.1	4247.6	2.41
			216 42 51	White Island Ledge	36 43 58	3465.0	3789.2	2.15
Herring, (hyd.)	44 57 06.90	66 54 36.23	114 42 01	Hannah	294 39 57	4222.3	4617.4	2.62
			217 58 13	White Horse	38 00 05	5621.6	6147.6	3.49
Casco Island, flag in tree	44 57 14.63	66 55 47.93	54 33 48	Indian Head	234 32 23	3239.0	3542.0	2.01
			123 57 01	Hannah	303 55 48	2730.5	2985.9	1.70
Johnnie	44 56 38.18	66 55 21.95	133 04 41	Hannah	313 03 10	3880.2	4243.3	2.41
			76 48 05	Indian Island	256 46 22	3295.8	3604.1	2.05
Green Island	44 56 56.14	66 56 17.01	142 09 33	Hannah	322 08 41	2653.5	2901.8	1.65
			229 56 04	White Horse	49 59 07	7403.5	8096.2	4.60
Pope's Folly	44 56 40.39	66 56 49.71	11 06 19	Friar's Head	191 05 31	7761.6	8487.8	4.82
			160 32 59	Hannah	340 32 30	2737.1	2993.2	1.70
Eastport, Congregationalist church.	44 54 14.99	66 58 54.03	133 05 58	Prince Regent's Redoubt	313 04 59	2496.6	2730.2	1.55
			338 28 47	Friar's Head	158 29 27	3362.3	3676.9	2.09
Fort Sullivan, flagstaff	44 54 25.23	66 58 55.04	127 39 50	Prince Regent's Redoubt	307 38 52	2274.8	2487.6	1.41
			339 58 13	Friar's Head	159 58 53	3665.6	4008.6	2.28
Moses House, west chimney	44 55 23.76	66 57 36.23	245 35 11	Hannabury	65 37 09	4034.0	4411.5	2.51
			5 09 37	Friar's Head	185 09 22	5272.1	5765.4	3.28

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Passamaquoddy Bay and St. Croix River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Campobello Island, (B.)	44 54 08.00	66 57 02.21	22 44 39	Friar's Head	202 44 00	3157.6	3453.0	1.96
			123 55 17	Perry Pigeon	303 50 55	8917.7	9752.1	5.54
East Beacon	44 49 48.99	66 57 26.59	79 05 22	Porcupine	259 02 53	4737.1	5180.4	2.94
			359 24 27	Quoddy	179 24 28	1797.9	1966.1	1.12
Carrying Place Church	44 48 36.52	66 58 54.33	189 36 54	Friar's Head	9 37 34	7423.8	8118.5	4.61
			257 16 49	Quoddy	77 17 51	1995.1	2181.8	1.24
Woodard's Point	44 50 11.99	66 59 00.15	58 13 34	Porcupine	238 12 11	3054.0	3339.8	1.90
			320 24 22	Quoddy	140 25 29	3254.4	3558.9	2.02
Lubec Church	44 51 37.29	66 58 54.70	339 10 59	Quoddy	159 12 02	5499.3	6013.9	3.42
			164 37 12	Prince Regent's Redoubt	344 36 14	6817.6	7455.5	4.24
Signal Flagstaff	44 51 39.92	66 58 55.36	150 34 30	Perry Pigeon	330 31 27	11534.5	12613.8	7.17
			217 16 47	Friar's Head	37 17 28	2083.8	2278.8	1.29
Lizard Signal	44 52 18.94	66 59 11.60	254 19 30	Friar's Head	74 20 22	1681.5	1838.8	1.04
			126 29 12	Comstock, (2)	306 28 02	2711.2	2964.9	1.68
Mark Island, flag in tree	44 52 04.72	66 58 42.79	159 18 57	Treat	339 18 43	1267.8	1386.4	0.79
			227 51 15	Friar's Head	47 51 47	1330.7	1455.2	0.83
Plaster Mill, chimney	44 51 31.63	67 00 20.10	238 28 45	Friar's Head	58 30 25	3662.7	4005.5	2.28
			180 32 53	Prince Regent's Redoubt	0 32 55	6748.3	7379.8	4.19
Pole on hill	44 52 33.39	67 00 50.79	188 39 47	Prince Regent's Redoubt	8 40 11	4897.7	5356.0	3.04
			269 51 38	Friar's Head	89 53 40	3795.8	4150.9	2.36
Comstock, (1)	44 52 49.40	67 00 44.03	167 12 42	Comstock, (2)	347 12 37	688.8	753.2	0.43
			274 58 45	Treat	94 59 56	2222.3	2430.2	1.38
Chimney of small Baptist church	44 52 53.88	67 01 00.81	201 32 40	Comstock, (2)	21 32 47	573.5	627.1	0.36
			314 17 44	Roger	134 18 29	1952.5	2135.2	1.21
Shackford	44 54 00.55	67 00 37.73	307 22 59	Friar's Head	127 24 52	4416.4	4829.6	2.74
			149 02 00	Perry Pigeon	329 00 10	6652.5	7274.9	4.13
Tinker's Island, flag	44 58 28.45	66 55 03.70	244 45 06	White Horse	64 47 17	4489.3	4909.4	2.79
			40 58 23	Indian Island	220 56 27	5503.9	6018.9	3.42
Spectacle Island, flag	44 59 09.16	66 54 41.60	259 34 30	White Horse	79 36 25	3636.5	3976.8	2.26
			37 06 09	Indian Island	217 03 57	6785.5	7420.4	4.22
Hannabury Tree	44 56 31.56	66 54 47.74	2 45 14	Hannabury	182 45 13	426.8	466.7	0.26
			95 24 56	Perry Pigeon	275 18 58	11143.9	12186.7	6.92
White Head	45 01 21.42	66 51 31.17	9 50 51	White Horse	189 50 32	3476.5	3801.8	2.16
			24 47 54	Hannabury	204 45 34	10323.7	11289.6	6.41
Hospital Island	44 59 19.44	66 54 31.66	264 12 33	White Horse	84 14 21	3375.9	3691.8	2.10
			36 57 45	Indian Island	216 55 26	7170.1	7841.0	4.46
Nubble	44 59 34.24	66 54 01.21	9 44 06	Hannabury	189 43 33	6153.5	6729.3	3.82
			38 49 57	Indian Island	218 47 17	7940.5	8683.5	4.93
Pleasant Point Church	44 57 21.12	67 02 02.91	27 30 59	Denboe	207 28 40	9368.9	10245.5	5.82
			72 37 35	Perry Pigeon	252 36 45	1668.5	1824.6	1.04
Pleasant Point, flagstaff	44 57 26.26	67 02 05.41	178 33 41	Navy	358 33 32	10820.1	11832.5	6.72
			66 43 06	Perry Pigeon	246 42 18	1633.9	1786.8	1.02
Leighton's House, chimney	44 52 47.99	67 05 24.65	199 50 10	Perry Pigeon	19 51 42	8444.7	9234.8	5.25
			219 17 13	Denboe	39 17 16	155.3	169.8	0.10
Clam Cove	44 57 57.47	67 00 46.41	352 54 46	Prince Regent's Redoubt	172 55 07	5200.8	5687.5	3.23
			63 33 01	Perry Pigeon	243 31 17	3610.7	3948.6	2.24
Herring Cove, white rock	44 52 30.86	66 54 27.55	308 45 29	Bishop	128 51 08	13549.3	14817.1	8.42
			29 57 23	Quoddy	209 55 17	7840.4	8574.0	4.87
West Beacon	44 50 20.35	66 58 08.92	63 22 27	Porcupine	243 20 28	4163.2	4552.7	2.59
			287 47 21	Indian Point	107 48 17	1819.2	1989.5	1.13
Liberty Point, flag in tree	44 49 55.71	66 55 32.97	81 14 05	Porcupine	261 10 16	7281.7	7963.1	4.52
			96 53 46	Indian Point	276 52 52	1705.4	1865.0	1.06
Liberty Point Ledge	44 49 40.04	66 55 47.22	54 53 39	Quoddy	234 52 29	2645.8	2893.3	1.64
			116 31 11	Indian Point	296 30 27	1542.0	1686.3	0.96
West Bliss	45 01 27.52	66 50 26.65	29 03 12	White Horse	209 02 07	4133.2	4519.9	2.57
			56 00 19	Hannah	235 55 19	11223.1	12273.3	6.97
East Bliss	45 02 03.14	66 49 14.33	37 19 01	White Horse	217 17 05	5924.9	6479.3	3.68
			114 49 29	Anley	294 47 17	4493.1	4913.5	2.79
Calliff	45 02 54.02	66 49 54.49	95 38 22	Anley	275 36 38	3214.6	3515.4	2.00
			72 15 18	North Head	252 10 36	9161.7	10019.0	5.69
Deadman Head	45 02 30.66	66 46 32.80	52 03 24	White Horse	231 59 33	9040.1	9886.0	5.62
			97 46 56	Anley	277 42 50	7682.7	8401.6	4.77

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

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	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Pea Point	45 02 30.56	66 47 52.19	100 03 26	Anley	280 00 16	5966.6	6524.9	3.71
			79 44 33	North Head	259 38 24	11588.1	12672.4	7.20
Mascabin	45 02 19.00	66 53 05.80	36 28 43	Hannah	216 25 35	9783.8	10699.3	6.08
			69 17 32	North Head	249 15 05	4851.0	5304.9	3.01
Barns	45 00 09.74	66 53 40.49	197 57 34	Anley	17 58 30	5661.5	6191.2	3.52
			298 27 02	White Horse	118 28 14	2545.3	2783.5	1.58
Mowatt	44 59 58.01	66 54 06.65	201 57 59	Anley	21 59 14	6198.1	6778.1	3.85
			7 43 13	Hannabury	187 42 43	6860.5	7502.4	4.26
Simpson	44 59 55.88	66 54 29.46	134 56 36	North Head	314 55 09	3823.6	4181.3	2.38
			283 19 31	White Horse	103 21 18	3402.0	3720.3	2.11
Adam	45 00 48.66	66 54 04.07	208 23 16	Anley	28 24 29	4756.7	5201.8	2.96
			6 40 13	Hannabury	186 39 42	8418.7	9206.4	5.23
Fish	45 00 35.42	66 55 14.27	295 01 47	White Horse	115 04 05	4736.7	5179.9	2.94
			130 37 45	North Head	310 36 49	2273.4	2486.1	1.41
Mink	44 59 27.05	66 55 47.70	164 31 34	North Head	344 31 02	3725.2	4073.8	2.31
			268 46 34	White Horse	88 49 16	5025.6	5495.8	3.12
St. Helena	44 59 22.23	66 56 12.19	35 41 00	Hannah	215 40 04	2971.4	3249.4	1.85
			173 01 35	North Head	353 01 20	3767.0	4119.5	2.34
Mowe	44 59 35.44	66 56 51.82	187 01 15	North Head	7 01 28	3357.3	3671.5	2.08
			17 02 44	Hannah	197 02 16	2951.5	3227.6	1.83
Higgins	44 59 52.39	66 55 47.57	34 12 12	Hannah	214 10 59	4043.3	4421.6	2.51
			160 27 54	North Head	340 27 22	2980.0	3258.8	1.85
Hardwood	45 00 58.45	66 55 15.94	302 05 38	White Horse	122 07 58	5109.1	5587.2	3.17
			114 29 13	North Head	294 28 18	1855.9	2029.6	1.15
Graveyard	45 00 59.94	66 55 47.85	22 39 28	Hannah	202 38 15	5883.7	6434.2	3.66
			298 46 11	White Horse	118 48 54	5735.6	6272.3	3.56
Butler	45 01 12.24	66 56 12.28	348 36 01	Hannabury	168 37 00	9272.6	10140.2	5.76
			235 41 11	Anley	55 43 55	6134.7	6708.7	3.81
Chimney of white house, with white roof.	45 04 38.11	66 54 25.31	316 44 21	Anley	136 45 49	3978.2	4350.5	2.47
			1 54 00	Hannabury	181 53 43	15453.1	16899.1	9.60
Hoy	45 01 58.87	66 55 16.01	316 36 20	White Horse	136 38 40	6302.8	6892.6	3.92
			22 14 44	Hannah	202 13 08	7830.8	8563.6	4.87
Parker	45 01 50.48	66 54 45.14	70 30 44	North Head	250 29 28	2506.7	2741.2	1.56
			234 13 37	Anley	54 15 19	3894.9	4259.4	2.42
Pendleton	45 01 53.66	66 56 59.07	303 50 37	White Horse	123 54 10	7930.4	8672.4	4.93
			135 52 47	Chamcook	315 47 21	14435.4	15786.1	8.97
Macmaster	45 02 41.11	66 55 35.85	260 29 43	Anley	80 32 01	4329.4	4734.5	2.69
			126 52 13	Chamcook	306 45 48	14835.6	16223.7	9.22
Matthews	45 03 44.35	66 54 17.16	34 22 04	North Head	214 20 28	5271.3	5764.5	3.28
			338 47 47	White Horse	158 49 25	8405.7	9192.2	5.22
Clark's Point, unpainted house, chimney.	45 05 28.41	66 54 18.04	330 01 06	Anley	150 02 29	5137.7	5618.4	3.19
			344 31 08	White Horse	164 32 47	11464.5	12537.2	7.18
Clark's Point, yellow house, chimney.	45 05 21.37	66 54 30.74	326 05 51	Anley	146 07 23	5100.5	5577.7	3.17
			20 01 56	North Head	200 00 29	7819.1	8550.8	4.86
Clark's Point, flagstaff	45 05 22.46	66 54 55.38	16 09 51	North Head	196 08 42	7683.5	8402.4	4.77
			68 11 09	Navy	248 05 56	10426.7	11402.3	6.48
Oak Head	44 58 17.94	67 00 52.63	224 46 37	North Head	44 49 40	8066.0	8820.8	5.01
			54 06 44	Perry Pigeon	234 05 04	3821.2	4178.7	2.37
Gardner's Point	44 59 16.28	67 00 09.75	230 23 31	North Head	50 26 04	6155.7	6731.7	3.82
			158 51 48	Chamcook	338 48 37	16313.5	17839.9	10.14
Davidson's Head	45 00 18.71	66 58 54.39	140 59 34	Navy	320 57 10	7071.7	7733.4	4.39
			237 09 18	North Head	57 10 58	3681.8	4026.3	2.29
Perry, north gable of barn	44 57 40.89	67 02 30.84	171 14 10	Chamcook	351 12 39	18372.7	20091.9	11.41
			181 34 15	Navy	1 34 24	10368.9	11339.1	6.44
Perry, south gable of fish-house	44 59 15.95	67 03 00.68	187 11 31	Navy	7 12 01	7490.1	8190.9	4.65
			171 58 12	Chamcook	351 57 02	15373.9	16812.5	9.55
Perry, chimney of white house with red door.	44 59 58.62	67 03 54.70	254 49 00	North Head	74 54 13	10016.8	10954.0	6.22
			199 07 05	Navy	19 08 14	6471.2	7076.7	4.02
Perry, south chimney of yellow house with dormer windows.	45 00 05.46	67 04 00.66	256 09 57	North Head	76 15 14	10090.2	11034.3	6.27
			200 51 42	Navy	20 52 55	6317.6	6908.7	3.93
Perry, southeast gable of yellow house.	45 00 47.34	67 04 31.25	212 19 26	Navy	32 21 00	5456.0	5966.6	3.39
			263 53 11	North Head	83 58 50	10527.0	11512.1	6.54

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	° ′ ″	° ′ ″	° ′ ″		° ′ ″	Metres.	Yards.	Miles.
Perry, chimney of one-story white house on Point.	45 01 43.76	67 04 52.66	273 14 30 181 36 21	North Head Chamcook	93 20 24 1 36 31	10954.0 10664.5	11979.0 11662.3	6.81 6.63
Robbinston, chimney of two-story yellow house.	45 03 25.76	67 06 52.93	145 15 26 272 37 53	Shortland Navy	325 14 03 92 41 08	4498.8 6025.2	4919.7 6589.0	2.80 3.74
Robbinston, white spire	45 05 02.87	67 06 21.15	318 03 08 102 06 46	Hannah Shortland	138 09 23 282 05 01	17368.6 3332.8	18993.8 3644.7	10.79 2.07
Beacon on west side of St. Andrew's	45 04 15.06	67 03 43.75	108 00 15 299 18 23	Shortland North Head	287 56 38 119 23 28	7045.1 10811.0	7704.3 11822.6	4.38 6.72
Navy Island Beacon	45 03 27.09	67 01 45.73	299 08 17 65 26 19	North Head Navy	119 11 58 245 25 56	7834.4 772.4	8567.5 844.6	4.87 0.48
Beacon No. 1	45 03 44.35	67 00 26.27	310 25 40 70 42 32	North Head Navy	130 28 25 250 41 13	6704.8 2585.4	7332.1 2827.3	4.17 1.61
Chimney of house on bluff	45 05 15.16	67 02 37.48	333 14 38 311 51 58	Hannah North Head	153 18 15 131 56 16	14899.0 10713.1	16293.1 11715.5	9.26 6.66
West end of barn on Minister Island.	45 06 14.87	67 02 12.22	4 33 07 337 53 15	Perry Pigeon Hannah	184 32 23 157 56 34	17016.3 16350 1	18608.5 17880.0	10.57 10.16
Block House	45 04 36.96	67 04 32.10	299 38 25 104 54 06	North Head Shortland	119 44 04 284 51 03	12067.8 5842.8	13196.9 6389.5	7.50 3.63
St. Andrew's, short white spire	45 04 44.84	67 03 05.62	158 05 22 0 43 51	Chamcook Perry Pigeon	338 04 16 180 43 45	5466.6 14184.4	5978.1 15511.6	3.40 8.81
St. Andrew's, tall white spire	45 04 35.84	67 02 52.69	156 32 05 1 54 52	Chamcook Perry Pigeon	336 30 50 181 54 37	5831.4 13913.2	6377.0 15215.1	3.62 8.65
St. Andrew's, flagstaff	45 04 49.15	67 02 50.81	345 48 13 330 44 58	Navy Hannah	165 48 36 150 48 44	2943.3 14328.2	3218.7 15668.9	1.83 8.90
St. Andrew's, light-house	45 04 04.74	67 02 28.89	329 38 11 155 45 01	Hannah Chamcook	149 41 42 335 43 29	12900.6 6919.9	14107.7 7567.4	8.02 4.30
New Brunswick, chimney at east end of white house.	45 08 54.80	67 07 19.33	17 05 39 307 01 39	Shortland Chamcook	197 04 35 127 03 33	6758.5 4389.3	7390.9 4800.0	4.20 2.73
Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, Englishman's Bay, and Machias Bay.								
MOUNT DESERT	44 21 03.86	68 13 15.48						
HOWARD	44 37 45.30	67 23 22.85	65 14 10	Mount Desert	244 39 12	72982.2	79811.1	45.35
Pigeon	44 27 17.54	67 53 01.92	243 33 56 66 52 24	Howard Mount Desert	63 54 44 246 38 15	43788.9 29222.7	47886.2 31957.1	27.21 18.16
Burke	44 35 54.65	67 58 07.95	337 01 28 265 32 52	Pigeon Howard	157 05 02 85 57 17	17331.5 46094.4	18953.2 50407.4	10.77 28.64
Mitten	41 43 19.33	67 39 45.38	295 22 51 30 41 44	Howard Pigeon	115 34 22 210 32 25	23968.3 34494.0	26211.0 37721.6	14.89 21.43
Moose-a-bec	44 30 08.74	67 30 56.45	215 20 22 154 30 32	Howard Mitten	35 25 40 334 24 21	17283.7 27044.4	18900.9 29574.9	10.74 16.81
White	44 32 49.23	67 44 26.50	107 36 22 48 05 16	Burke Pigeon	287 26 45 227 59 15	19004.4 15310.5	20782.6 16743.0	11.80 9.51
Tucker	44 31 08.01	68 10 39.90	10 28 09 286 49 21	Mount Desert Pigeon	190 26 20 107 01 42	18960.8 24433.1	20734.9 26719.2	11.78 15.18
Schoodic	44 21 01.67	68 02 50.49	90 20 26 151 01 43	Mount Desert Tucker	270 13 09 330 56 14	13840.7 21399.9	15135.8 23402.3	8.60 13.30
Hovey	44 29 18.32	68 01 49.89	5 00 11 44 53 10	Schoodic Mount Desert	184 59 29 224 45 10	15386.9 21514.1	16826.6 23527.2	9.56 13.17
Ash	44 24 37.02	68 05 33.56	331 28 46 150 44 00	Schoodic Tucker	151 30 40 330 40 25	7563.2 13837.1	8270.9 15131.9	4.70 8.60
Baker's Island Light	44 14 27.39	68 11 36.34	223 42 59 169 49 43	Schoodic Mount Desert	43 49 06 349 48 34	16850.5 12432.0	18427.2 13595.3	10.47 7.72
Petit Manan Light, chimney	44 22 02.17	67 51 30.87	82 59 39 134 34 35	Schoodic Hovey	262 51 44 314 27 22	15163.9 19198.9	16582.8 20995.3	9.42 11.93
Petit Manan, old light-tower	44 22 02.26	67 51 30.10	168 13 05 148 55 18	Pigeon Tunk	348 12 01 328 45 38	9940.3 35335.5	10870.4 38641.8	6.18 21.96
Beacon	44 16 46.86	68 13 02.88	239 50 48 177 59 10	Schoodic Mount Desert	59 57 56 357 59 01	15684.0 7936.8	17151.5 8679.4	9.75 4.93

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, &c.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Square House, south chimney	44 28 12.82	68 05 31.79	128 29 34	Tucker	308 25 58	8692.7	9506.1	5.40
			37 48 52	Mount Desert	217 43 28	16748.2	18315.3	10.40
Light-keeper's House, chimney	44 21 40.34	68 04 55.74	84 14 22	Mount Desert	264 08 32	11122.9	12163.6	6.91
			293 16 12	Schoodic	113 17 40	3019.3	3301.8	1.87
Burnt	44 23 57.63	68 11 13.53	295 56 54	Schoodic	116 02 46	12389.0	13548.2	7.70
			260 47 06	Ash	80 51 04	7619.5	8332.5	4.73
Long	44 24 04.95	68 09 38.39	174 03 44	Tucker	354 03 01	13127.6	14355.9	8.16
			302 01 34	Schoodic	122 06 20	10654.8	11651.7	6.62
Jordan	44 24 56.08	68 07 32.83	319 10 00	Schoodic	139 13 18	9560.1	10454.6	5.94
			160 13 11	Tucker	340 11 00	12201.7	13343.4	7.58
Wheeler	44 23 11.26	68 10 30.42	42 54 38	Mount Desert	222 52 42	5367.0	5869.1	3.34
			248 01 09	Ash	68 04 37	7081.4	7744.0	4.40
Grindstone	44 22 50.59	68 05 21.59	175 24 02	Ash	355 23 54	3295.5	3603.8	2.05
			155 24 13	Tucker	335 20 30	16888.1	18468.3	10.49
Church at Winter Harbor	44 23 30.60	68 05 04.75	67 25 04	Mount Desert	247 19 20	11769.6	12870.9	7.31
			327 05 53	Schoodic	147 07 27	5473.6	5985.7	3.40
Egg	44 21 13.43	68 07 56.70	273 02 32	Schoodic	93 06 06	6790.3	7425.6	4.22
			87 38 31	Mount Desert	267 34 48	7064.7	7725.7	4.39
Church at Bar Harbor	44 23 13.35	68 12 02.22	288 20 58	Schoodic	108 27 24	12872.7	14077.2	8.00
			253 14 52	Ash	73 19 24	8979.3	9819.5	5.58
Young	44 18 35.99	68 11 04.73	147 37 32	Mount Desert	327 36 01	5405.9	5911.7	3.36
			247 37 47	Schoodic	67 43 32	11834.8	12942.1	7.35
Chimney of small white house with dark roof.	44 25 48.87	68 06 01.13	148 00 15	Tucker	327 57 00	11617.6	12704.6	7.22
			47 34 49	Mount Desert	227 29 45	13029.4	14248.6	8.09
St. Bernard	44 24 10.31	68 05 29.63	328 48 17	Schoodic	148 50 08	6804.7	7441.4	4.23
			173 56 55	Ash	353 56 52	828.9	906.4	0.51
Mosquito Harbor Light	44 21 40.07	68 04 55.57	84 17 05	Mount Desert	264 11 15	11125.6	12166.5	6.91
			293 09 29	Schoodic	113 10 56	3012.9	3294.8	1.87
Newport	44 21 01.69	68 11 18.29	182 35 38	Tucker	2 36 05	18731.4	20484.1	11.64
			91 30 28	Mount Desert	271 29 06	2596.0	2838.9	1.61
Twice	44 28 03.82	68 11 00.53	12 59 02	Mount Desert	192 57 28	13300.6	14545.2	8.27
			320 11 17	Schoodic	140 17 00	16949.6	18535.6	10.53
Chimney of house on Iron-bound island.	44 23 28.53	68 07 55.57	236 02 40	Ash	56 04 19	3788.1	4142.6	2.35
			57 47 46	Mount Desert	237 44 02	8372.9	9156.4	5.21
Stave	44 26 16.36	68 08 04.86	312 29 11	Ash	132 30 57	4538.6	4963.3	2.82
			324 21 16	Schoodic	144 24 56	11946.6	13064.4	7.42
Calf	44 27 41.64	68 08 45.84	158 25 30	Tucker	338 24 10	6849.6	7490.5	4.25
			323 14 48	Ash	143 17 03	7109.4	7774.7	4.42
Sullivan Church, No. 1	44 30 37.22	68 09 34.57	333 15 21	Schoodic	153 20 03	19885.0	21745.7	12.35
			334 22 15	Ash	154 25 04	12327.0	13480.3	7.66
Sullivan Church, No. 2	44 29 24.40	68 09 46.85	329 16 10	Schoodic	149 21 01	18043.7	19731.9	11.21
			327 42 24	Ash	147 45 21	10488.8	11470.2	6.52
Wallace	44 34 01.85	67 51 47.32	7 31 40	Pigeon	187 30 47	12587.3	13765.1	7.82
			194 25 37	East Base	14 27 10	11685.1	12778.4	7.26
Bee	44 23 26.18	67 57 42.63	56 49 47	Schoodic	236 46 11	8145.2	8907.4	5.06
			287 27 17	Petit Manan Light	107 31 37	8627.9	9435.2	5.36
Nash's Island Light, chimney	44 27 50.54	67 44 29.88	139 54 50	Wallace	319 49 44	14988.5	16391.0	9.31
			84 54 28	Pigeon	264 48 29	11364.1	12427.4	7.06
Cromer	44 26 32.05	68 00 54.88	14 05 47	Schoodic	194 04 26	10512.6	11496.2	6.53
			262 18 27	Pigeon	82 23 58	10550.3	11537.5	6.56
Newman	44 25 13.17	67 58 18.49	241 14 00	Pigeon	61 17 42	7983.4	8730.4	4.96
			37 49 21	Schoodic	217 46 11	9822.8	10742.0	6.11
Eagle Hill	44 27 32.38	67 55 24.36	333 06 02	Petit Manan Light	153 08 45	11426.2	12495.3	7.10
			278 16 10	Pigeon	98 17 47	3181.4	3479.1	1.98
Hathaway	44 22 30.97	68 01 22.14	35 22 49	Schoodic	215 21 47	3380.3	3696.6	2.10
			220 21 18	Eagle Hill	40 25 28	12214.5	13357.3	7.59
Hatch	44 24 30.57	68 00 36.22	24 45 39	Schoodic	204 44 05	7099.2	7763.5	4.41
			173 43 13	Cromer	353 43 00	3771.9	4124.9	2.35
Pearl	44 23 36.60	67 58 55.77	154 03 57	Cromer	334 02 34	6021.7	6585.2	3.74
			195 27 45	Newman	15 28 11	3092.5	3381.8	1.92
Hale	44 19 51.74	68 01 33.97	184 00 08	Cromer	4 00 35	12385.5	13544.4	7.70
			141 51 48	Schoodic	321 50 55	2744.0	3000.8	1.70

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

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Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
West chimney of house at head of Gouldsborough Bay.	44 27 56.97	67 59 12.53	40 49 22	Cromer	220 48 10	3462.3	3786.2	2.15
			278 32 17	Eagle Hill	98 34 57	5100.2	5577.4	3.17
Gouldsborough, east chimney of two-story white house.	44 28 52.13	68 01 58.97	341 51 11	Cromer	161 51 56	4549.6	4975.3	2.83
			324 10 42	Newman	144 13 16	8332.3	9111.9	5.18
Chimney of house, frame of building to the west.	44 24 03.77	67 58 14.34	177 32 29	Newman	357 32 26	2143.8	2344.4	1.33
			328 49 44	Bee	148 50 06	1355.8	1482.6	0.84
Steuben, white spire	44 30 36.50	67 57 23.60	143 59 00	Tunk	323 53 27	17772.9	19435.9	11.04
			174 18 42	Burke	354 18 11	9868.5	10791.9	6.13
Dyer	44 24 41.86	67 55 40.67	119 06 31	Cromer	296 02 54	7336.5	8023.0	4.56
			105 28 46	Newman	285 26 56	3622.8	3961.8	2.25
West gable-end of barn, east side of Dyer's Bay.	44 26 00.33	67 54 14.75	214 02 24	Pigeon	34 03 15	2875.7	3144.7	1.79
			74 54 58	Newman	254 52 07	5583.9	6106.4	3.47
Chimney of unpainted house, east side of Dyer's Bay.	44 25 12.49	67 54 20.97	105 46 53	Cromer	285 42 17	9050.9	9897.8	5.62
			204 21 22	Pigeon	24 22 17	4236.4	4632.8	2.63
Chimney of house, east side of Dyer's Bay.	44 25 17.75	67 54 09.34	104 22 55	Cromer	284 18 11	9257.0	10123.1	5.75
			201 57 23	Pigeon	21 58 10	3985.8	4358.7	2.48
Petit	44 23 42.61	67 53 39.51	118 32 43	Cromer	298 27 38	10958.5	11983.9	6.81
			187 08 22	Pigeon	7 08 48	6684.9	7310.5	4.16
North chimney of house, west side of Dyer's Bay.	44 25 15.66	67 55 30.08	51 14 13	Schoodic	231 09 05	12508.3	13678.7	7.77
			221 02 37	Pigeon	41 04 21	4988.0	5454.7	3.10
West chimney of white house on Rogers's Point.	44 28 20.28	67 57 59.34	4 11 43	Newman	184 11 30	5790.3	6332.1	3.60
			49 17 35	Cromer	229 15 32	5120.0	5599.1	3.18
Hemlock	44 26 46.42	67 58 36.21	137 37 15	Hovey	317 34 59	6348.3	6942.3	3.94
			352 14 32	Newman	172 14 44	2904.4	3176.1	1.81
Spoon	44 26 45.63	67 57 05.85	126 55 24	Hovey	306 52 05	7849.5	8584.0	4.88
			29 23 19	Newman	209 22 28	3274.6	3581.0	2.04
Cherryfield spire	44 36 01.44	67 55 07.71	107 56 09	Tunk	287 49 00	14132.0	15454.4	8.78
			87 00 12	Burke	266 58 06	3980.1	4352.5	2.47
Mill River Church, with square steeple.	44 35 51.27	67 50 21.23	12 37 43	Pigeon	192 35 50	16248.3	17768.7	10.10
			103 19 48	Tunk	283 09 18	20305.0	22205.0	12.62
Mitchell	44 33 58.76	67 46 37.26	161 02 54	East Base	341 00 49	12066.4	13195.4	7.50
			34 29 13	Pigeon	214 24 43	15017.3	16422.4	9.33
Clump	44 34 13.42	67 48 11.42	170 26 38	East Base	350 25 39	11113.1	12152.9	6.91
			26 34 58	Pigeon	206 31 34	14350.1	15692.8	8.92
Ripley	44 31 33.22	67 47 34.28	170 29 42	East Base	350 28 17	16125.3	17634.1	10.02
			42 33 40	Pigeon	222 29 50	10708.9	11710.9	6.65
Fort	44 32 33.47	67 50 21.30	121 08 21	Burke	301 02 54	12023.1	13148.1	7.47
			20 00 38	Pigeon	199 58 45	10376.7	11347.6	6.45
Foster	44 31 36.20	67 49 39.59	121 16 23	Tunk	301 05 24	24190.5	26454.0	15.03
			29 15 42	Pigeon	209 13 21	9150.6	10006.9	5.69
Log	44 30 03.93	67 48 04.54	52 01 06	Pigeon	231 57 38	8340.3	9120.7	5.18
			223 18 55	White	43 21 28	7014.1	7670.4	4.36
Millbridge Church, No. 1, tall white spire.	44 32 19.54	67 52 38.24	123 48 18	Tunk	303 39 25	20144.6	22029.5	12.52
			132 25 17	Burke	312 21 26	9849.3	10770.9	6.12
Millbridge Church, No. 2	44 31 50.68	67 52 35.11	125 44 50	Tunk	305 35 55	20709.7	22647.5	12.87
			194 36 10	Wallace	14 36 44	4183.6	4575.0	2.60
Flint	44 29 37.87	67 46 49.60	73 16 06	Pigeon	253 11 45	8594.5	9398.7	5.34
			295 18 26	Nash's Island Light	115 20 04	3415.6	3735.2	2.12
Trafton	44 29 21.00	67 49 14.73	52 49 19	Pigeon	232 46 40	6303.2	6893.0	3.92
			224 41 34	White	44 44 56	9044 7	9891.0	5.62
Turner	44 30 09.60	67 51 24.95	21 59 04	Pigeon	201 57 56	5726.7	6262.5	3.56
			187 27 15	East Base	7 28 32	18641.5	20385.7	11.58
Bois Bubert	44 26 25.76	67 51 53.85	136 42 46	Pigeon	316 41 58	2195.3	2400.7	1.36
			255 01 47	Nash's Island Light	75 06 58	10157.6	11108.0	6.31
North chimney of white house on north end of Pond Island.	44 27 49.41	67 49 58.06	76 24 37	Pigeon	256 22 28	4181.7	4573.0	2.60
			133 58 26	Tunk	313 47 41	28163.8	30799.1	17.50
Jordan's Delight	44 26 34.31	67 49 06.82	208 07 29	White	28 10 45	13123.7	14351.6	8.16
			104 24 28	Pigeon	284 22 03	5365.7	5867.7	3.34
Chimney of two-story, salmon-colored house.	44 28 50.80	67 56 00.30	306 07 19	Pigeon	126 09 24	4881.2	5337.9	3.03
			341 49 45	Eagle Hill	161 50 10	2547.4	2785.8	1.58
Chimney of two-story house, with ends painted red.	44 28 23.42	67 55 14.50	304 44 55	Pigeon	124 46 28	3566.4	3900.1	2.22
			7 52 42	Eagle Hill	187 52 35	1590.1	1738.9	0.99

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	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Chimney of house at head of Dyer's bay.	44 29 26.77	67 54 21.44	335 25 36	Pigeon	155 26 34	4385.8	4796.1	2.73
			20 33 50	Eagle Hill	200 33 08	3770.6	4123.5	2.35
Pinkham	44 28 31.77	67 54 00.70	330 26 54	Pigeon	150 27 35	2633.9	2880.4	1.64
			45 15 13	Eagle Hill	225 14 15	2603.6	2847.2	1.62
White chimney of house at head of Pigeon Hill bay.	44 29 23.02	67 53 17.97	341 13 29	Bois Bubert	161 14 28	5778.2	6318.9	3.59
			354 46 36	Pigeon	174 46 47	3889.3	4253.3	2.42
Chimney of two-story house, east side of bay.	44 27 57.79	67 51 53.20	0 17 06	Bois Bubert	180 17 06	2840.4	3106.1	1.77
			50 43 41	Pigeon	230 42 53	1962.6	2146.2	1.22
Harrington, tall white spire with turrets.	44 37 11.69	67 48 05.50	95 32 52	Tunk	275 20 46	22856.3	24995.0	14.20
			79 54 44	Burke	259 47 41	13493.8	14756.5	8.38
Chimney of white house, Cape Split Harbor.	44 32 01.26	67 42 07.37	58 51 52	Pigeon	238 44 13	16904.8	18486.5	10.50
			115 44 39	White	295 43 01	3409.4	3728.4	2.12
Cape Split	44 29 53.67	67 44 13.14	176 52 52	White	356 52 43	5425.5	5933.2	3.37
			268 24 33	Moose-a-bec	88 33 51	17605.1	19252.4	10.94
Chimney of house, west side of bay.	44 26 28.49	67 53 05.05	182 36 21	Pigeon	2 36 23	1515.1	1656.9	0.94
			273 03 24	Bois Bubert	93 04 14	1576.7	1724.2	0.98
Chimney of dark brown house on east side of bay.	44 27 10.18	67 51 51.86	1 49 52	Bois Bubert	181 49 51	1371.7	1500.1	0.85
			98 20 17	Pigeon	278 19 28	1565.9	1712.4	0.97
Chimney of red house, west side of Dyer's bay.	44 26 24.71	67 55 43.46	191 26 02	Eagle Hill	11 26 15	2130.5	2329.8	1.33
			245 27 04	Pigeon	65 28 57	3925.5	4292.8	2.44
Pond Island Light	44 27 20.49	67 49 32.30	166 28 40	Wallace	346 27 05	12741.2	13933.3	7.92
			213 37 25	White	33 40 59	12188.5	13329.0	7.57
Ryefield	44 36 44.16	67 36 04.98	158 19 28	Mitten	338 16 53	13127.1	14355.4	8.16
			330 48 44	Moose-a-bec	150 52 20	13976.0	15283.8	8.68
Kelly	44 33 40.31	67 37 48.01	79 52 20	White	259 47 40	8934.6	9770.6	5.55
			305 39 48	Moose-a-bec	125 44 37	11190.2	12237.2	6.95
Crumple	44 26 33.04	67 35 34.55	222 41 36	Moose-a-bec	42 44 50	9060.8	9908.6	5.63
			134 42 15	White	314 36 02	16519.3	18065.0	10.26
Beals	44 30 28.64	67 36 47.42	113 13 00	White	293 07 38	11025.6	12057.2	6.85
			274 29 54	Moose-a-bec	94 34 00	7777.2	8504.9	4.83
Indian Hill	44 44 18.23	67 26 49.60	41 09 54	Ryefield	221 03 23	18601.3	20341.7	11.55
			83 59 50	Mitten	263 50 44	17164.2	18770.3	10.66
Libby Island Light	44 34 04.68	67 21 41.79	161 54 04	Howard	341 52 53	7163.3	7833.6	4.45
			104 31 53	Ryefield	284 24 47	19663.0	21502.9	12.21
Davis	44 39 03.09	67 12 52.69	80 15 06	Howard	260 07 43	14091.7	15410.3	8.76
			117 54 38	Indian Hill	297 44 49	20835.8	22785.4	12.95
Dwelley	44 43 40.02	67 24 03.22	355 20 42	Howard	175 21 11	10984.8	12012.6	6.83
			107 52 30	Indian Hill	287 50 33	3845.7	4205.5	2.39
Wass	44 35 36.78	67 45 04.32	71 47 51	Wallace	251 43 08	9360.3	10236.1	5.82
			350 49 55	White	170 50 22	5238.5	5728.7	3.25
Look	44 35 27.94	67 43 45.18	10 32 47	White	190 32 18	4982.9	5449.2	3.10
			98 53 32	Wass	278 52 37	1766.5	1931.8	1.10
Moose	44 33 20.20	67 38 57.12	247 50 59	Kelly	67 51 48	1646.9	1801.0	1.02
			331 35 04	Beals	151 36 35	6019.7	6583.0	3.74
Joe Looks's House, chimney	44 34 17.57	67 44 39.23	167 14 42	Wass	347 14 24	2506.6	2741.1	1.56
			354 07 20	White	174 07 29	2741.3	2997.8	1.70
Charles Wooster's House, chimney.	44 34 43.05	67 45 19.29	191 15 51	Wass	11 16 02	1690.8	1849.0	1.05
			236 16 18	Look	56 17 24	2495.7	2729.2	1.55
Easternmost of three trees on hill.	44 37 01.06	67 44 55.64	331 36 10	Look	151 36 59	3267.3	3573.0	2.03
			4 12 35	Wass	184 12 29	2608.5	2852.6	1.62
Church at Addison Point	44 37 10.98	67 44 13.69	348 49 02	Look	168 49 22	3242.4	3545.8	2.02
			21 00 32	Wass	200 59 57	3115.0	3406.5	1.94
South chimney of white house, with long L.	44 36 17.03	67 43 55.03	351 50 35	Look	171 50 42	1530.8	1674.1	0.95
			50 53 23	Wass	230 52 34	1969.4	2153.7	1.22
Small brown house, chimney	44 35 51.29	67 43 54 42	344 12 45	Look	164 12 52	749.1	819.2	0.46
			73 48 03	Wass	253 47 14	1605.2	1755.4	1.00
Moose-a-bec Light, or Head Harbor Light.	44 28 26.73	67 31 34.86	115 29 50	White	295 20 49	18869.3	20634.9	11.72
			231 24 16	Libby Island Light	51 31 12	16742.6	18309.1	10.40
Hardwood	44 30 46.81	67 39 16.98	118 57 45	White	298 54 08	7808.3	8538.9	4.85
			276 01 03	Moose-a-bec	96 06 54	11118.2	12158.5	6.91
Rake	44 28 42.25	67 34 50.41	242 40 26	Moose-a-bec	62 43 10	5818.2	6362.6	3.61
			120 58 52	White	300 52 08	14831.0	16218.8	9.22

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Section 1.—Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, &c.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Browny	44 27 46.18	67 36 41.41	239 58 38	Moose-a-bec	60 02 40	8801.9	9625.5	5.47
			132 21 35	White	312 16 09	13892.5	15192.4	8.63
Stevens	44 29 23.47	67 39 41.96	313 51 40	Crumple	133 54 31	7587.5	8297.5	4.71
			135 19 44	White	315 16 24	8933.6	9769.5	5.55
Outer Sand	44 27 43.87	67 40 03.39	249 38 42	Moose-a-bec	69 45 05	12886.8	14092.5	8.01
			148 21 44	White	328 18 39	11071.6	12107.6	6.88
Hall's Hill, flagstaff	44 35 06.78	67 38 48.79	60 21 40	White	240 17 43	8576.5	9379.0	5.33
			230 13 34	Ryefield	50 15 29	4699.2	5138.9	2.92
Indian River Church, No. 1	44 34 21.85	67 38 13.99	70 51 27	White	250 47 06	8703.4	9517.8	5.41
			212 55 28	Ryefield	32 56 59	5233.2	5722.9	3.25
Indian River Church, No. 2	44 34 22.83	67 38 16.43	70 33 08	White	250 28 48	8662.5	9473.0	5.38
			213 35 53	Ryefield	33 37 25	5237.5	5727.6	3.25
Rogue	44 35 11.03	67 30 23.72	4 25 21	Moose-a-bec	184 24 58	9358.3	10234.0	5.81
			195 34 55	Indian Hill	15 37 25	17534.8	19175.5	10.90
Woodard	44 33 33.42	67 34 19.45	84 14 37	White	264 07 31	13466.3	14726.3	8.37
			324 37 25	Moose-a-bec	144 39 47	7746.7	8471.5	4.81
Great Spruce	44 33 30.73	67 29 23.88	124 03 03	Ryefield	303 58 21	10672.7	11671.4	6.63
			18 08 49	Moose-a-bec	198 07 44	6561.0	7174.9	4.08
Mark	44 31 50.14	67 31 48.89	339 41 46	Moose a-bec	159 42 23	·336.8	3649.0	2.07
			225 28 22	Howard	45 34 17	15645.3	17109.2	9.72
Flat	44 27 36.43	67 42 08.84	162 31 45	White	342 30 08	10121.4	11068.4	6.29
			207 07 42	Kelly	27 10 45	12622.0	13803.1	7.84
Norton	44 32 06.77	67 36 45.83	97 23 08	White	277 17 45	10252.6	11211.9	6.37
			351 18 03	Crumple	171 18 53	10419.8	11394.8	6.47
Chandler	44 32 21.50	67 40 25.57	288 00 20	Moose-a-bec	108 06 59	13218.9	14455.7	8.21
			99 09 54	White	279 07 05	5386.3	5890.3	3.35
Doyle	44 31 47.37	67 38 28.99	286 53 51	Moose-a-bec	106 59 08	10447.9	11425.5	6.49
			103 37 40	White	283 33 29	8119.6	8879.4	5.04
Head Harbor	44 30 39.01	67 33 05.95	23 24 20	Crumple	203 22 36	8271.5	9045.4	5.14
			160 42 05	Ryefield	340 39 59	10942.2	11966.1	6.80
Plummer	44 29 08.84	67 41 30.69	262 25 23	Moose-a-bec	82 32 48	14133.9	15456.4	8.78
			301 25 16	Crumple	121 27 26	9223.9	10087.0	5.73
Church at Jonesport	44 32 00.44	67 35 26.81	32 09 02	Beals	212 08 05	3346.5	3659.6	2.08
			236 15 03	Howard	56 23 31	19193.0	20988.9	11.92
Sawyer	44 37 32.48	67 32 36.21	138 36 05	Mitten	318 31 03	14280.9	15617.2	8.87
			350 51 30	Moose-a-bec	170 52 40	13871.6	15169.6	8.62
Shoppe	44 37 18.76	67 28 58.21	11 07 37	Moose-a-bec	191 06 14	13526.8	14792.5	8.41
			192 19 33	Indian Hill	12 21 03	13252.9	14493.0	8.24
The Brothers	44 33 23.80	67 25 49.15	135 00 33	Mitten	314 50 46	26027.7	28463.1	16.18
			201 46 35	Howard	21 48 18	8691.8	9505.1	5.40
Starboard	44 36 13.30	67 23 54.53	39 38 57	Moose-a-bec	219 34 01	14605.1	15971.7	9.08
			193 49 00	Howard	13 49 22	2924.4	3198.0	1.82
Chimney of house on Libby Island, (northernmost island.)	44 34 56.72	67 20 56.13	56 12 14	Moose-a-bec	236 05 13	15955.5	17448.4	9.92
			99 29 05	Ryefield	279 18 27	20315.2	22216.1	12.62
Rogers	44 35 55.79	67 33 12.25	255 21 49	Howard	75 28 43	13427.1	14683.5	8.34
			111 25 04	Ryefield	291 23 03	4091.8	4474.7	2.54
Cross	44 36 16.27	67 18 09.07	142 25 34	Indian Hill	322 19 28	18781.2	20538.5	11.67
			111 41 56	Howard	291 38 16	7442.2	8138.6	4.63
Machias, white spire	44 42 56.39	67 27 08.12	251 39 51	Dwelley	71 42 01	4285.8	4686.8	2.66
			189 10 28	Indian Hill	9 10 41	2558.0	2797.3	1.59
School-house at Machias Point	44 41 49.48	67 23 29.18	136 10 28	Indian Hill	316 08 07	6367.1	6962.9	3.96
			290 03 36	Davis	110 11 04	14929.9	16326.9	9.28
Buck's	44 39 18.89	67 22 31.75	272 07 57	Davis	92 14 44	12767.4	13962.0	7.93
			148 27 35	Indian Hill	328 24 34	10843.8	11858.5	6.74
Lowell	44 42 27.28	67 20 00.50	303 44 23	Davis	123 49 24	11334.2	12394.7	7.04
			27 08 07	Howard	207 05 45	9777.8	10692.7	6.08
Sprague	44 39 28.07	67 19 12.42	140 33 48	Dwelley	320 30 23	10072.6	11015.1	6.26
			131 42 40	Indian Hill	311 37 18	13471.8	14732.4	8.37
Thornton	44 37 34.14	67 16 22.49	138 06 12	Dwelley	318 00 48	15181.8	16602.4	9.43
			132 09 03	Indian Hill	312 01 42	18606.8	20347.7	11.56
Machias Town-hall, cupola	44 43 01.41	67 27 01.64	186 22 34	Indian Hill	6 22 42	2385.8	2609.0	1.48
			253 05 56	Dwelley	73 08 02	4103.0	4486.9	2.55

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Gouldsborough Bay, Narraguagus Bay, Pleasant Bay, Chandler's Bay, &c.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Captain Burnham's House, chimney	44 43 15.61	67 26 21.08	162 00 58	Indian Hill	342 00 38	2032.1	2222.2	1.26
			256 02 20	Dwelley	76 03 57	3125.6	3418.0	1.94
Old Church opposite Machias Port	44 42 03.36	67 22 45.68	127 49 05	Indian Hill	307 46 13	6792.4	7427.9	4.22
			150 14 18	Dwelley	330 13 24	3436.8	3758.3	2.14
Seal Island, east light	44 30 06.35	67 05 45.48	178 59 29	Trescott Rock	358 59 13	28543.2	31214.0	17.74
			121 22 02	Howard	301 09 40	27293.8	29847.7	16.96
Little Kennebec	44 38 58.55	67 26 17.90	300 21 49	Howard	120 23 52	4471.2	4889.6	2.78
			356 29 10	The Brothers	176 29 30	10351.0	11319.5	6.43
New Barn, north gable	44 36 45.92	67 25 44.97	239 39 30	Howard	59 41 10	3629.3	3968.9	2.25
			169 57 07	Little Kennebec	349 56 44	4157.7	4546.7	2.58
Yellow House, east chimney	44 40 48.98	67 27 09.61	341 30 56	Little Kennebec	161 51 32	3593.6	3929.8	2.23
			318 35 40	Howard	138 38 20	7556.3	8263.4	4.70
White House, west chimney	44 40 11.62	67 25 30.83	24 41 45	Little Kennebec	204 41 12	2481.9	2714.2	1.55
			328 00 37	Howard	148 02 07	5324.2	5822.4	3.31
Bell	44 46 31.68	67 16 41.32	207 02 05	Arcus	27 05 57	15925.6	17415.7	9.90
			28 35 08	Howard	208 30 26	18494.5	20225.0	11.49
Dennison	44 38 27.23	67 13 48.49	84 13 00	Howard	264 06 16	12723.5	13914.0	7.91
			227 57 05	Davis	47 57 44	1652.2	1806.8	1.03
Old Man	44 37 08.97	67 13 51.13	200 02 50	Davis	20 03 31	3749.0	4099.7	2.33
			181 22 53	Dennison	1 22 55	2415.9	2641.9	1.50
Chimney of house with frame of barn to east.	44 40 07.48	67 15 27.04	324 56 01	Dennison	144 57 10	3780.2	4133.9	2.35
			300 19 01	Davis	120 20 49	3936.7	4305.0	2.45
Sandy Point	44 40 22.08	67 09 02.89	347 04 39	Seal Island, east light	167 06 57	19496.7	21321.0	12.11
			64 18 18	Davis	244 15 37	5620.9	6146.9	3.50
Colville	44 39 36.52	67 12 45.53	8 48 54	Davis	188 48 49	1045.0	1142.8	0.65
			76 19 28	Howard	256 12 00	14456.1	15808.8	8.98
Lookout	44 39 23.01	67 11 34.97	70 15 23	Davis	250 14 28	1822.5	1993.0	1.13
			241 25 45	Sandy Point	61 27 32	3814.1	4171.0	2.37
Ravine	44 41 18.61	67 08 18.88	55 17 06	Davis	235 13 53	7341.2	8028.1	4.56
			200 13 45	Trescott Rock	20 15 17	8303.0	9079.9	5.16
Bog Creek	44 43 05.08	67 06 30.72	186 13 42	Trescott Rock	6 13 58	4529.7	4953.5	2.81
			48 25 58	Davis	228 21 29	11250.7	12303.5	6.99
Penobscot Bay and River.								
Isle au Haut	44 04 01.90	68 36 42.51	....	....	....	....	....	.....
Fox Rocks	44 06 26.90	68 52 21.53	282 00 03	Isle au Haut	102 10 56	21361.7	23360.5	13.27
North Fox	44 10 51.45	68 49 17.74	306 54 02	Isle au Haut	127 02 48	21015.0	22981.4	13.06
			26 35 37	Fox Rocks	206 33 29	9129.2	9983.5	5.67
Deer Isle	44 13 24.20	68 39 48.68	346 34 20	Isle au Haut	166 36 30	17839.8	19509.1	11.08
			52 28 28	Fox Rocks	232 19 44	21108.4	23083.5	13.12
Burnt Cove	44 09 18.59	68 40 50.78	71 01 36	Fox Rocks	250 53 35	16242.3	17762.1	10.09
			190 18 16	Deer Isle	10 18 59	7704.4	8425.3	4.79
Coombs Hill	44 05 17.38	68 46 51.63	106 19 53	Fox Rocks	286 16 03	7644.1	8359.4	4.75
			162 31 52	North Fox	342 30 10	10809.4	11820.9	6.72
Swan's Island	44 09 43.97	68 25 00.12	56 00 34	Isle au Haut	235 52 25	18850.2	20614.0	11.71
			109 05 37	Deer Isle	288 55 18	20867.9	22820.5	12.97
Patterson	44 22 17.38	69 02 56.75	298 00 18	Deer Isle	118 16 27	34890.9	38155.7	21.68
			334 16 35	Fox Rocks	154 23 58	32544.1	35589.3	20.22
Whitmore's Harbor, church spire	44 11 09.16	68 37 01.90	279 14 36	Swan's Island	99 22 59	16245.9	17766.1	10.09
			358 07 33	Isle au Haut	178 07 47	13193.0	14427.5	8.20
Northwest Harbor, church spire	44 13 13.55	68 40 15.97	6 05 07	Burnt Cove	186 04 43	7292.3	7974.6	4.53
			344 24 37	Isle au Haut	164 27 06	17673.6	19327.3	10.98
Northwest Harbor, parsonage	44 13 19.47	68 39 56.44	345 55 15	Isle au Haut	165 57 31	17739.1	19399.0	11.02
			52 30 13	Fox Rocks	232 21 34	20882.9	22836.9	12.98
North end of Deer Isle, north church spire.	44 16 10.68	68 40 01.16	348 52 49	Isle au Haut	168 55 07	22920.2	25064.8	14.24
			51 28 39	North Fox	231 22 11	15799.7	17278.1	9.82
North end of Deer Isle, south church spire.	44 15 50.80	68 40 04.76	53 04 49	North Fox	232 58 23	15361.6	16798.9	9.55
			43 18 18	Fox Rocks	223 09 45	23886.5	26121.6	14.84
Brooklin, church spire	44 16 00.69	68 33 47.19	9 58 28	Isle au Haut	189 56 26	22522.2	24629.6	14.00
			58 58 35	Deer Isle	238 54 23	9361.8	10237.8	5.82
Kent's Hill	44 08 58.67	68 50 05.53	327 43 16	Coombs Hill	147 45 31	8075.9	8831.6	5.02
			32 51 11	Fox Rocks	212 49 36	5574.8	6096.4	3.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section 1—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Stimpson's Island	44 08 09.72	68 49 02.90	54 19 00	Fox Rocks	234 16 42	5437.7	5946.5	3.38
			258 57 17	Burnt Cove	79 03 00	11140.7	12183.2	6.92
Stinson's Point, flag in tree	44 10 19.07	68 42 41.84	307 05 21	Burnt Cove	127 06 38	3094.3	3383.8	1.92
			96 31 12	North Fox	276 26 36	8850.1	9678.2	5.50
Calderwood's Neck, tree with tuft	44 06 39.96	68 49 32.47	305 27 12	Coombs Hill	125 29 04	4391.8	4802.8	2.73
			182 24 49	North Fox	2 24 50	7768.5	8495.4	4.83
Brimstone Island, flag in tree	44 00 44.77	68 45 48.28	140 23 00	Fox Rocks	320 18 27	13713.9	14997.1	8.52
			202 37 27	Burnt Cove	22 40 54	17182.7	18790.5	10.68
Tree with tuft, near Fox Rocks	44 06 26.80	68 51 52.28	90 15 15	Fox Rocks	270 14 55	650.5	711.3	0.40
			231 13 21	Deer Isle	51 21 45	20599.2	22526.7	12.80
Job Banks's House, chimney	44 09 43.24	68 49 09.00	339 34 24	Coombs Hill	159 36 00	8754.7	9573.8	5.44
			174 43 42	North Fox	354 43 36	2114.2	2312.0	1.31
Babbidge's Island, flag in tree	44 08 32.26	68 46 41.67	259 34 35	Burnt Cove	79 38 40	7927.0	8668.8	4.93
			141 06 25	North Fox	321 04 36	5520.5	6037.0	3.43
Eagle Island Light	44 13 02.61	68 45 44.05	324 08 34	Isle au Haut	144 14 51	20571.9	22496.8	12.79
			316 40 11	Burnt Cove	136 43 35	9495.7	10384.2	5.90
Deer Isle, square-tower church	44 11 41.45	68 39 24.90	39 59 37	Coombs Hill	219 54 26	15461.3	16908.0	9.61
			23 24 09	Burnt Cove	203 22 09	4803.9	5253.4	2.98
Saddleback Light	44 00 50.58	68 43 15.24	191 34 11	Burnt Cove	11 35 52	16003.8	17501.3	9.94
			235 55 36	Isle au Haut	56 00 09	10550.0	11537.2	6.56
Saddleback Island	44 00 50.00	68 43 15.65	149 47 49	Coombs Hill	329 45 19	9550.0	10443.6	5.93
			191 35 18	Burnt Cove	11 36 59	16023.5	17522.8	9.96
Mark Island Light	44 08 02.69	68 41 51.79	210 03 54	Burnt Cove	30 04 36	2706.4	2959.6	1.68
			52 36 20	Coombs Hill	232 32 56	8395.3	9180.8	5.22
Church spire on Isle au Haut	44 04 24.66	68 37 42.70	127 45 28	North Fox	307 37 24	19524.4	21351.3	12.13
			155 16 08	Burnt Cove	335 13 57	9988.7	10923.3	6.21
Jesse Calderwood's House, chimney.	44 06 48.81	68 48 11.72	327 43 50	Coombs Hill	147 44 46	3336.6	3648.8	2.07
			168 55 12	North Fox	348 54 26	7630.9	8344.9	4.74
Spruce Head	44 14 21.33	68 49 06.64	278 03 05	Deer Isle	98 09 34	12506.0	13676.2	7.77
			2 10 51	North Fox	182 10 43	6482.0	7088.5	4.03
Bradbury's Island, flag in tree	44 14 40.71	68 45 21.80	287 41 37	Deer Isle	107 45 29	7759.2	8485.3	4.82
			36 31 54	North Fox	216 29 09	8802.9	9626.6	5.47
Pickering's Island, flag in tree	44 15 43.57	68 44 32.13	304 20 41	Deer Isle	124 23 59	7618.9	8331.8	4.73
			35 08 19	North Fox	215 05 00	11020.8	12052.0	6.85
Ojier	44 11 43.48	69 03 12.12	104 15 52	Ragged Mount	284 12 01	7590.9	8301.2	4.72
			303 59 21	Fox Rocks	124 06 55	17448.0	19080.6	10.84
Gilkey	44 14 23.53	68 55 10.25	80 24 57	Ragged Mount	260 15 30	18308.6	20021.7	11.37
			65 15 27	Ojier	245 09 51	11780.9	12883.3	7.32
Garey	44 15 45.25	69 00 42.67	288 50 58	Gilkey	108 54 50	7793.4	8522.6	4.84
			23 58 42	Ojier	203 56 58	8165.4	8929.4	5.07
Dyer	44 08 40.16	68 54 15.99	328 14 45	Fox Rocks	148 16 04	4836.2	5288.7	3.01
			173 31 07	Gilkey	353 30 29	10665.2	11663.1	6.63
Pigeon Hill	44 08 03.73	68 52 46.94	349 17 32	Fox Rocks	169 17 50	3041.2	3325.7	1.89
			119 36 50	Dyer	299 35 48	2276.2	2489.2	1.41
Calderwood Rock	44 07 33.92	68 50 08.14	55 07 10	Fox Rocks	235 05 37	3615.6	3953.9	2.25
			104 37 28	Pigeon Hill	284 35 37	3647.7	3989.0	2.27
Mark Island, flag in tree	44 10 20.66	68 58 38.16	310 43 16	Fox Rocks	130 47 38	11050.3	12084.2	6.87
			211 36 12	Gilkey	31 38 37	8802.5	9626.1	5.47
Duck Trap, church spire	44 17 26.14	69 00 09.67	310 02 11	North Fox	130 09 46	18910.8	20680.3	11.75
			332 53 39	Fox Rocks	152 59 05	22846.8	24984.5	14.20
Temperance	44 19 04.23	68 58 18.44	341 14 28	Fox Rocks	161 18 37	24679.4	26988.7	15.34
			334 15 48	Gilkey	154 18 00	9615.5	10515.2	5.98
McIntire, flag in tree	44 10 52.00	69 03 29.83	39 31 01	Bear Hill	219 29 14	5355.4	5856.5	3.33
			193 54 24	Ojier	13 54 36	1636.6	1789.7	1.02
Mount Battie, flag in tree	44 13 21.36	69 03 48.78	80 01 10	Ragged Mount	259 57 44	6643.5	7265.1	4.13
			260 29 01	Gilkey	80 35 03	11665.3	12756.8	7.25
Lasell's Island, flag in tree	44 11 42.40	68 57 22.47	210 32 14	Gilkey	30 33 46	5773.9	6314.2	3.59
			90 16 51	Ojier	270 12 47	7763.6	8490.0	4.82
Grindle's Point Light	44 16 52.54	68 56 14.67	342 43 57	Gilkey	162 44 42	4815.7	5266.3	2.99
			70 45 49	Garey	250 42 42	6295.2	6884.2	3.91
Graves	44 10 55.29	69 01 46.67	128 05 29	Ojier	308 04 31	2410.8	2636.4	1.50
			189 00 46	Garey	9 01 31	9060.6	9908.4	5.63

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

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Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Negro Island Light	44 12 03.86	69 02 36.09	200 12 37	Garey	20 13 54	7281.2	7962.5	4.52
			246 25 06	Gilkey	66 30 17	10793.1	11803.0	6.71
Turner's House, chimney	44 10 02.58	68 51 53.21	151 30 39	Gilkey	331 28 22	9164.6	10022.1	5.69
			246 23 21	North Fox	66 25 09	3768.4	4121.0	2.34
Blake's Point	44 18 34.81	68 47 33.04	312 54 14	Deer Isle	132 59 38	14069.3	15385.8	8.74
			230 05 50	Blue Hill	50 14 32	21521.1	23534.8	13.38
Little Deer Isle	44 17 10.04	68 42 09.47	60 40 13	Spruce Head	240 35 22	10616.5	11609.9	6.60
			39 09 47	North Fox	219 04 48	15060.8	16470.1	9.36
Billings	44 18 53.61	68 39 50.92	55 45 40	Spruce Head	235 39 12	14914.5	16310.0	9.27
			359 43 13	Deer Isle	179 43 15	10166.5	11117.8	6.32
Little Torry Island	44 14 54.75	68 34 42.50	112 53 11	Little Deer Isle	292 47 59	10755.7	11762.1	6.68
			137 10 52	Billings	317 07 17	10054.9	10995.8	6.25
Naskeag Point	44 14 04.93	68 31 39.04	168 16 54	Blue Hill	348 14 29	22586.4	24699.8	14.04
			129 17 30	Billings	309 11 47	14082.7	15400.5	8.75
J. Simpson's Barn, west gable	44 13 18.20	68 43 18.68	192 06 05	Little Deer Isle	12 06 53	7318.0	8002.7	4.55
			60 25 51	North Fox	240 21 41	9168.5	10026.4	5.70
Barn on Hog Island, south gable	44 17 01.56	68 47 10.65	27 29 46	Spruce Head	207 28 25	5574.1	6095.7	3.46
			170 13 08	Blake's Point	350 12 52	2920.3	3193.5	1.81
Pumpkin Island Light	44 18 31.99	68 44 14.43	39 58 32	Spruce Head	219 55 08	10090.9	11035.1	6.27
			91 08 57	Blake's Point	271 06 38	4402.3	4814.2	2.74
S. Black's House, chimney	44 18 09.90	68 43 35.60	46 10 17	Spruce Head	226 06 26	10180.7	11133.3	6.33
			330 15 50	Deer Isle	150 18 28	10152.5	11102.4	6.31
D. Eaton's House, chimney	44 13 24.95	68 42 43.83	186 15 17	Little Deer Isle	6 15 41	6988.8	7642.7	4.34
			101 36 46	Spruce Head	281 32 19	8670.7	9482.0	5.39
Dead-top Tree	44 14 00.76	68 47 19.31	229 36 07	Little Deer Isle	49 39 43	9019.5	9863.5	5.60
			104 56 04	Spruce Head	284 54 49	2464.3	2694.9	1.53
Lone Spruce Tree	44 17 35.42	68 48 09.67	11 54 52	Spruce Head	191 54 12	6121.6	6694.3	3.80
			203 52 44	Blake's Point	23 53 10	2004.5	2192.0	1.25
Bakeman's Hill	44 21 11.50	68 46 58.45	326 30 39	Deer Isle	146 35 39	17285.4	18902.8	10.74
			319 18 07	Little Deer Isle	139 21 29	9824.6	10743.9	6.10
Billings' Mount, flag in tree	44 19 05.41	68 42 19.82	307 17 55	Little Torry Island	127 23 14	12753.0	13946.3	7.92
			276 17 11	Billings	96 18 55	3319.6	3630.2	2.06
Carter's House, north chimney	44 17 04.38	68 36 52.45	324 13 21	Little Torry Island	144 14 52	4930.5	5391.8	3.06
			91 27 18	Little Deer Isle	271 23 37	7030.5	7688.3	4.37
F. Johnson's House, chimney	44 15 26.86	68 37 56.52	158 20 03	Billings	338 18 43	6866.4	7508.9	4.27
			282 56 52	Little Torry Island	102 59 07	4416.2	4829.4	2.74
Bass Harbor Head Light	44 13 18.03	68 19 54.22	52 38 38	Isle au Haut	232 26 56	28225.1	30866.1	17.54
			45 49 14	Swan's Island	225 45 41	9282.6	10151.1	5.77
Fly Island Light	44 14 54.49	68 29 32.39	61 26 50	Naskeag Point	241 25 22	3199.2	3498.6	1.99
			160 15 36	Blue Hill	340 11 43	21874.0	23920.8	13.59
Bluff	44 13 19.88	68 32 26.78	134 12 24	Little Torry Island	314 10 49	4200.3	4593.3	2.61
			217 17 50	Naskeag Point	37 18 23	1748.0	1911.5	1.09
Lone Tree	44 13 51.66	68 34 32.85	173 43 31	Little Torry Island	353 43 24	1958.9	2142.2	1.22
			263 55 12	Naskeag Point	83 57 13	3878.4	4241.3	2.41
Cape Rosier	44 19 13.31	68 49 02.62	0 33 56	Spruce Head	180 33 53	9011.3	9854.5	5.60
			88 45 00	Temperance	268 38 32	12318.8	13471.4	7.65
Dickey's Bluff	44 21 29.82	68 57 16.10	291 01 52	Cape Rosier	111 07 37	11714.2	12810.3	7.28
			320 35 11	Spruce Head	140 40 53	17104.7	18705.1	10.63
Castine	44 23 17.28	68 48 35.65	4 32 12	Cape Rosier	184 31 53	7553.4	8260.2	4.69
			58 52 34	Temperance	238 45 47	15084.2	16495.6	9.37
Moose Point	44 25 43.83	68 56 19.52	9 04 38	Dickey's Bluff	189 03 58	7939.0	8681.8	4.93
			293 44 21	Castine	113 49 46	11214.9	12264.3	6.97
Patershal's Hill	44 26 50.10	69 00 54.83	333 53 39	Dickey's Bluff	153 56 12	11006.1	12036.0	6.84
			17 47 06	Patterson	197 45 41	8838.2	9665.3	5.49
Cape Jellison	44 27 07.48	68 50 51.20	60 55 08	Patterson	240 46 40	18379.2	20099.0	11.42
			39 17 31	Dickey's Bluff	219 13 02	13458.1	14717.4	8.36
Kedear's Hill	44 22 23.13	68 53 14.27	316 24 12	Cape Rosier	136 27 08	8086.0	8842.6	5.02
			254 48 35	Castine	74 51 50	6389.6	6987.5	3.97
Mount Ephraim	44 31 26.31	68 56 54.60	25 19 54	Patterson	205 15 40	18738.6	20492.0	11.64
			1 28 54	Dickey's Bluff	181 28 39	18415.7	20138.8	11.44
Little Ball	44 29 18.14	68 44 19.08	103 24 38	Mount Ephraim	283 15 48	17149.4	18754.1	10.66
			65 05 04	Cape Jellison	245 00 29	9558.0	10452.3	5.94

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Webster	44 26 37.05	68 46 51.63	214 07 51 20 28 39	Little Ball Castine	34 09 38 200 27 27	6007.4 6580.8	6569.5 7196.6	3.73 4.09
Perry	44 33 32.30	68 43 34.01	7 14 03 100 13 56	Little Ball Mount Waldo, (B)	187 13 31 280 07 04	7907.4 13168.1	8647.3 14400.3	4.91 8.18
Sandy Point	44 30 35.69	68 48 36.39	292 48 37 141 03 10	Little Ball Mount Waldo, (B)	112 51 37 320 59 50	6167.2 10093.7	6744.3 10939.7	3.83 6.21
McCloud's	44 32 58.79	68 46 53.14	77 55 34 333 26 27	Mount Ephraim Little Ball	257 48 32 153 28 15	13580.5 7612.9	14851.2 8325.3	8.44 4.73
Bucksport	44 34 44.71	68 46 58.26	15 44 47 296 21 44	Sandy Point Perry	195 43 38 116 24 07	7985.6 5030.5	8732.8 5501.2	4.96 3.13
Cobb's Hill	44 38 52.47	68 48 15.78	41 45 40 327 48 48	Mount Waldo, (B) Perry	221 42 05 147 52 06	10124.2 11672.7	11071.5 12765.0	6.29 7.25
Treat's	44 36 26.30	68 51 12.59	220 48 22 299 10 51	Cobb's Hill Bucksport	40 50 26 119 13 49	5961.3 6425.9	6519.1 7027.2	3.70 3.99
Trevett's	44 39 03.30	68 50 51.38	22 45 51 5 30 40	Mount Waldo, (B) Treat's	202 44 06 185 30 25	8555.7 4868.2	9356.2 5323.7	5.32 3.03
Mark Island 2	44 15 29.30	68 51 22.90	304 43 56 125 47 39	Spruce Head Temperance	124 45 31 305 42 49	3679.1 11352.0	4023.4 12414.2	2.29 7.05
Isleboro', south church	44 17 23.03	68 54 09.63	49 00 24 70 56 18	Ojier Garey	228 54 06 250 51 44	15958.5 9222.7	17451.7 10085.7	9.92 5.73
Isleboro', Baptist church	44 19 55.41	68 53 35.25	226 46 00 120 48 09	Castine Dickey's Bluff	46 49 29 300 45 35	9100.5 5693.3	9952.0 6226.0	5.66 3.54
Decker's House, chimney	44 20 42.61	68 52 21.04	159 12 00 102 35 56	Kedear's Hill Dickey's Bluff	339 11 23 282 32 30	3318.6 6694.4	3629.1 7320.8	2.06 4.16
Sears House, west chimney	44 25 54.70	68 52 23.67	340 13 12 313 53 57	Cape Rosier Castine	160 15 33 133 56 37	13163.6 7003.6	14395.3 7658.9	8.18 4.35
Sandy Point, Congregationalist church, white spire.	44 30 42.44	68 48 31.34	0 23 47 22 07 28	Castine Kedear's Hill	180 23 44 202 04 10	13737.2 16631.3	15022.6 18187.5	8.54 10.33
Sandy Point, Universalist church, gray spire.	44 30 39.36	68 48 32.59	0 16 58 22 09 27	Castine Kedear's Hill	180 16 56 202 06 10	13643.7 16533.7	14920.3 18080.7	8.48 10.27
Dice's Head Light	44 22 56.89	68 48 48.52	60 25 08 76 35 57	Temperance Dickey's Bluff	240 18 30 256 30 02	14521.2 11553.4	15879.9 12634.4	9.02 7.18
Seal Island, flag in tree	44 19 39.26	68 55 17.26	74 56 41 142 22 03	Temperance Dickey's Bluff	254 54 34 322 20 40	4157.3 4309.4	4546.3 4712.6	2.58 2.68
Head of Tide, church spire	44 26 56.89	69 02 59.05	274 21 05 359 39 52	Patershal's Hill Patterson	94 22 32 179 39 54	2754.5 8626.1	3012.2 9433.3	1.71 5.36
Belfast Monument, (Steel's ledge)	44 25 08.52	68 58 00.76	51 09 02 244 02 02	Patterson Moose Point	231 05 35 64 03 13	8414.0 2490.0	9201.3 2723.0	5.23 1.55
Belfast, Methodist church spire	44 25 28.54	68 59 59.08	284 55 54 264 25 58	Castine Moose Point	105 03 52 84 28 32	15653.9 4879.6	17118.7 5336.2	9.73 3.03
Conner's Steam Mill, chimney	44 25 15.18	68 59 24.41	257 46 50 337 46 40	Moose Point Dickey's Bluff	77 48 59 157 48 10	4183.8 7512.8	4575.3 8215.8	2.60 4.67
Gilmore's House, east chimney	44 25 50.54	68 57 37.47	276 50 40 356 38 00	Moose Point Dickey's Bluff	96 51 35 176 38 15	1736.2 8060.7	1898.7 8815.0	1.08 5.01
Searsport, tall spire	44 27 34.26	68 55 10.41	278 10 58 13 53 55	Cape Jellison Dickey's Bluff	98 14 00 193 52 27	5789.3 11586.3	6331.0 12670.4	3.60 7.20
Stockton, church spire	44 29 26.25	68 51 07.65	343 32 34 29 01 48	Castine Dickey's Bluff	163 34 20 208 57 30	11873.2 16811.3	12984.2 18384.3	7.38 10.45
Turtle Head 2, flag in tree	44 23 29.45	68 52 32.27	24 25 39 274 04 35	Kedear's Hill Castine	204 25 10 94 07 21	2248.0 5250.1	2458.3 5741.3	1.40 3.26
Seurs Island, flag in tree	44 26 19.93	68 52 24.43	234 32 45 318 03 39	Cape Jellison Castine	54 33 50 138 06 19	2530.7 7575.5	2767.5 8284.3	1.57 4.71
Fort Point Light	44 28 00.74	68 48 22.22	63 29 02 246 00 21	Cape Jellison Little Ball	243 27 18 66 03 11	3680.7 5879.8	4025.1 6430.0	2.29 3.65
Fort Point Beacon	44 27 38.83	68 48 16.43	3 01 03 74 13 16	Castine Cape Jellison	183 00 50 254 11 28	8083.3 3555.1	8839.6 3887.8	5.02 2.21
Castine, Orthodox church spire	44 23 24.66	68 47 31.67	80 52 21 147 19 51	Castine Cape Jellison	260 51 36 327 17 31	1434.2 8171.0	1568.4 8935.6	0.89 5.08
Brooksville, church spire	44 23 40.22	68 45 05.47	81 21 58 28 35 34	Castine Bakeman's Hill	261 19 31 208 34 15	4704.6 5226.8	5144.8 5715.8	2.92 3.25
Jones	44 25 12.58	68 45 10.92	115 16 03 188 35 41	Cape Jellison Little Ball	295 12 05 8 36 17	8318.4 7664.9	9096.8 8382.1	5.17 4.76

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
North Castine Flagstaff	44 24 50.12	68 46 09.67	48 26 22	Castine	228 24 40	4317.8	4721.8	2.68
			124 16 49	Cape Jellison	304 13 32	7531.8	8236.6	4.68
Steel's Flagstaff	44 25 34.20	68 47 55.01	126 28 52	Cape Jellison	306 26 49	4843.9	5297.2	3.02
			12 01 02	Castine	192 00 34	4320.4	4724.6	2.68
Buker's Flagstaff	44 25 37.00	68 45 57.94	147 21 31	Webster	327 20 53	2201.0	2407.0	1.37
			197 44 47	Little Ball	17 45 56	7166.5	7837.1	4.45
Odem's Ledge Beacon	44 30 54.92	68 47 42.90	351 53 47	Webster	171 54 23	8038.9	8791.1	4.99
			63 19 02	Sandy Point	243 18 25	1322.0	1445.7	0.82
Whitmore's House, east chimney	44 30 49.58	68 46 36.45	2 28 03	Webster	182 27 52	7801.2	8531.1	4.85
			80 48 44	Sandy Point	260 47 20	2683.0	2934.1	1.67
Chimney of house on Sandy Point	44 29 54.15	68 48 17.78	281 52 44	Little Ball	101 55 31	5389.3	5893.6	3.35
			342 36 51	Webster	162 37 51	6374.2	6970.6	3.96
Jerry Bowden's Red House, chimney.	44 28 51.72	68 46 14.66	252 16 37	Little Ball	72 17 58	2680.8	2931.7	1.67
			135 43 07	Sandy Point	315 41 28	4483.2	4902.7	2.79
Quarry, flag in tree	44 30 54.45	68 44 50.31	83 24 34	Sandy Point	263 21 56	5025.9	5496.2	3.12
			144 45 53	McCloud's	324 44 27	4699.0	5138.6	2.92
Orland Church, tall spire	44 34 22.35	68 44 21.68	93 48 25	Mount Waldo, (B)	273 42 07	11933.5	13050.1	7.41
			359 38 58	Little Ball	179 39 00	9389.4	10268.0	5.83
Bucksport Church, east spire	44 34 24.53	68 47 15.68	14 15 52	Sandy Point	194 14 55	7287.7	7969.6	4.53
			349 37 42	McCloud's	169 37 57	2690.1	2941.8	1.67
Bucksport Church, west spire	44 34 24.08	68 47 19.89	13 28 50	Sandy Point	193 27 56	7248.8	7927.0	4.50
			347 21 27	McCloud's	167 21 46	2697.6	2950.0	1.68
Fort Knox Flagstaff	44 33 54.51	68 47 50.81	323 30 32	McCloud's	143 31 09	2139.2	2339.4	1.33
			216 48 12	Bucksport	36 48 46	1935.6	2116.7	1.20
Indian Point, flag in tree	44 34 46.87	68 48 14.87	272 14 56	Bucksport	92 15 50	1691.1	1849.3	1.05
			331 35 51	McCloud's	151 36 48	3791.9	4146.7	2.36
Winterport Church, clock spire	44 38 09.93	68 50 28.15	245 45 20	Cobb's Hill	65 46 53	3198.6	3497.9	1.99
			162 44 46	Trevett's	342 44 30	1725.2	1886.6	1.07
Sparks' House, chimney	44 32 14.20	68 45 12.90	121 53 52	McCloud's	301 52 42	2605.8	2849.6	1.62
			222 09 10	Perry	42 10 19	3252.0	3556.3	2.02
Shute's Hill, flag in tree	44 32 29.16	68 48 13.66	201 40 45	Bucksport	21 41 38	4502.3	4923.6	2.80
			242 45 37	McCloud's	62 46 33	1998.5	2185.5	1.24
Deserted	44 33 56.29	68 48 50.60	238 53 49	Bucksport	58 55 08	2894.2	3165.0	1.80
			276 01 18	Perry	96 05 00	7024.9	7682.3	4.36
Belfry	44 38 02.24	68 49 24.53	134 34 21	Trevett's	314 33 20	2686.1	2937.5	1.67
			41 02 42	Mount Waldo, (B)	220 59 56	7959.4	8704.2	4.95
Hopkins, flag in tree	44 33 50.79	68 45 48.78	137 21 57	Bucksport	317 21 08	2262.8	2474.6	1.41
			280 51 02	Perry	100 52 37	3028.3	3311.7	1.88
Lone Tree	44 37 15.29	68 49 09.54	146 03 41	Trevett's	326 02 29	4019.6	4395.0	2.50
			339 10 43	McCloud's	159 12 19	8468.6	9261.0	5.26
School-house, chimney	44 36 00.46	68 48 37.45	70 17 48	Mount Waldo, (B)	250 14 29	6654.8	7277.4	4.14
			103 08 34	Treat's	283 06 45	3512.7	3841.4	2.18
South Orrington, church spire	44 41 33.78	68 48 40.81	353 40 42	Cobb's Hill	173 41 00	5009.1	5477.8	3.11
			26 17 27	Mount Waldo, (B)	206 14 10	13977.1	15285.0	8.68
Orrington, church spire	44 43 50.67	68 49 12.52	352 15 54	Cobb's Hill	172 16 34	9288.2	10157.3	5.77
			18 08 40	Mount Waldo, (B)	198 05 45	17633.9	19283.9	10.96
Hampden, church tower 1	44 43 30.91	68 50 14.95	343 00 36	Cobb's Hill	163 02 00	8985.7	9826.5	5.58
			14 17 38	Mount Waldo, (B)	194 15 27	16664.1	18223.4	10.35
Hampden, church tower 2	44 44 20.89	68 49 59.04	347 20 57	Cobb's Hill	167 22 10	10388.5	11360.6	6.45
			14 09 57	Mount Waldo, (B)	194 07 35	18245.4	19952.6	11.33
Hampden, church tower 3	44 44 27.69	68 49 57.46	347 46 54	Cobb's Hill	167 48 05	10585.9	11576.5	6.58
			14 06 40	Mount Waldo, (B)	194 04 17	18457.7	20184.8	11.46
Chimney of house on west side of river.	44 35 25.20	68 49 40.12	166 52 16	Trevett's	346 51 26	6912.5	7559.3	4.30
			132 46 28	Treat's	312 45 23	2777.6	3037.5	1.73
Bangor, Methodist church	44 48 20.39	68 45 41.66	93 03 25	Thomas' Hill	273 02 45	1261.2	1379.2	0.78
			321 57 57	Saunders' Mount	142 04 47	20832.7	22782.1	12.95
Penobscot bay and St. George's river.								
RAGGED MOUNT	44 12 43.95	69 08 43.55						
MOUNT DESERT	44 21 03.86	68 13 15.48	78 30 46	Ragged Mount	257 52 03	75382.4	82435.9	46.84
Isle au Haut	44 04 01.90	68 36 42.51	110 51 38	Ragged Mount	290 29 20	45632.8	49902.7	28.35
			224 35 04	Mount Desert	44 51 25	44388.1	48541.5	27.58

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Section I.—Penobscot Bay and St. George's River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Woodenball	43 51 27.62	68 48 17.90	213 35 34	Isle au Haut	33 43 37	27966.6	30583.4	17.38
			145 24 19	Ragged Mount	325 10 07	47917.7	52401.3	29.77
Turkey Church	43 56 45.12	69 14 21.03	254 46 56	Isle au Haut	75 13 05	52081.6	56954.8	32.36
			194 12 16	Ragged Mount	14 16 11	30528.7	33385.2	18.97
Fox Rocks	44 06 26.90	68 52 21.53	118 10 08	Ragged Mount	297 58 44	24726.7	27040.3	15.37
			348 54 28	Wooden Ball	168 57 18	28278.5	30924.5	17.57
Hurricane	44 02 06.81	68 53 06.20	133 25 46	Ragged Mount	313 14 54	28650.5	31331.3	17.81
			341 55 20	Woodenball	161 58 40	20747.3	22688.6	12.89
High Island	44 00 47.73	69 03 15.24	63 17 08	Turkey Church	243 09 26	16619.8	18174.9	10.33
			259 44 11	Hurricane	79 51 14	13779.8	15069.2	8.56
Green Mount	43 54 10.16	69 00 08.39	287 28 45	Wooden Ball	107 36 57	16634.0	18190.5	10.34
			104 11 37	Turkey Church	284 01 45	19610.5	21445.4	12.18
St. George's Church	44 01 10.06	69 11 48.98	22 31 27	Turkey Church	202 29 42	8851.0	9679.2	5.50
			273 23 48	High Island	93 29 45	11462.3	12534.8	7 12
Bear Hill	44 08 38.11	69 06 03.18	345 32 56	High Island	165 34 53	14990.3	16392.9	9.31
			304 52 08	Hurricane	125 01 09	21083.7	23056.5	13.10
Metinic	43 53 35.98	69 07 13.90	156 23 30	St. George's Church	336 20 19	15296.3	16727.6	9.50
			201 44 43	High Island	21 47 29	14347.2	15689.7	8.91
Ingraham	44 04 55.76	69 06 31.35	330 17 09	High Island	150 19 25	8812.3	9636.9	5.48
			185 12 31	Bear Hill	5 12 51	6890.8	7535.6	4.28
Post Hill	44 05 10.52	69 04 15.15	81 28 28	Ingraham	261 26 53	3063.6	3350.2	1.90
			159 27 29	Bear Hill	339 26 14	6842.4	7482.6	4.25
False White Head	43 59 52.35	69 06 23.08	178 52 29	Ingraham	358 52 23	9365.7	10242.0	5.82
			196 09 42	Post Hill	16 11 11	10223.5	11180.1	6.35
Norton's Island	43 58 59.80	69 08 16.18	352 04 48	Metinic	172 05 32	10089.0	11033.0	6.27
			62 57 40	Turkey Church	242 53.27	9133.4	9988.0	5.67
Jameson	44 07 01.71	69 04 44.00	349 24 18	Post Hill	169 24 38	3491.7	3818.5	2.17
			149 24 08	Bear Hill	329 23 13	3457.1	3780.6	2.15
Little Green, (third-order signal)	43 54 50.91	69 01 48.43	72 22 14	Metinic	252 18 28	7621.5	8334.6	4.74
			220 49 02	Hurricane	40 55 05	17787.5	19451.9	11.05
Tenant's Harbor Church	43 57 58.58	69 12 43.31	191 34 21	St. George's Church	11 34 59	6032.4	6596.8	3.75
			43 52 05	Turkey Church	223 50 57	3144.4	3438.6	1.95
Tenant's Harbor Light	43 57 38.90	69 10 45.74	233 08 51	Norton's Island	53 10 35	4164.4	4554.0	2.59
			167 48 21	St. George's Church	347 47 37	6667.5	7291.4	4.14
Herring Gut Island	43 55 21.62	69 15 51.58	218 04 32	Turkey Church	38 05 35	3273.3	3579.6	2.03
			285 42 35	Metinic	105 48 34	12001.6	13124.5	7.46
Herring Gut Light	43 55 01.57	69 15 20.80	12 08 16	Monhegan	192 06 28	16610.9	18165.2	10.32
			283 36 59	Metinic	103 42 37	11180.5	12226.6	6.95
Heron Neck Light	44 01 29.70	68 51 23.16	85 23 54	High Island	265 15 38	15909.7	17398.4	9.89
			116 32 53	Hurricane	296 31 41	2564.4	2804.3	1.59
Owl's Head Light	44 05 30.76	69 02 18.93	8 09 48	High Island	188 09 09	8824.7	9650.4	5.48
			139 14 56	Bear Hill	319 12 20	7633.4	8347.6	4.74
Shears on Peabody's Island	43 59 16.98	69 04 04.48	171 20 27	Bear Hill	351 19 05	17517.9	19157.0	10.88
			250 15 37	Hurricane	70 23 14	15569.7	17026.5	9.67
Matinicus East Light	43 46 59.75	68 50 57.73	119 22 21	Metinic	299 11 05	24997.2	27336.2	15.53
			203 20 09	Wooden Ball	23 22 00	9007.3	9850.1	5.60
Matinicus West Light	43 47 01.16	68 50 59.13	174 13 17	Hurricane	354 11 49	28093.8	30722.6	17.46
			153 37 36	Ragged Mount	333 25 17	53191.6	58168.7	33.05
White Head Light	43 58 42.25	69 07 07.58	251 17 59	Hurricane	71 27 44	19775.8	21626.2	12.28
			233 10 45	High Island	53 13 26	6464.4	7069.3	4.02
Brown's Head Light	44 06 41.29	68 54 14.28	47 51 44	High Island	227 45 28	16247.0	17767.3	10.10
			102 57 09	Bear Hill	282 48 55	16165.9	17678.6	10.04
Lone Tree on Beach Hill	44 10 05.13	69 05 50.96	141 59 58	Ragged Mount	321 57 58	6223.6	6805.9	3.87
			348 35 54	High Island	168 37 42	17547.5	19189.4	10.90
Fiddler's Ledge, stone beacon	44 06 04.77	68 56 02.23	44 36 11	High Island	224 31 10	13732.8	15017.8	8.53
			331 54 11	Hurricane	151 56 14	8322.9	9101.7	5.17
Saddleback Light	44 00 50.62	68 43 15.24	21 15 38	Woodenball	201 12 08	18640.3	20384.4	11.58
			235 56 08	Isle au Haut	56 00 41	10548.8	11535.8	6.55
Dix Island, unpainted house, tall chimney in centre.	44 00 36.39	69 03 54.66	248 16 39	High Island	68 17 06	945.3	1033.7	0.59
			156 28 15	Ingraham	336 26 26	8731.7	9548.8	5.43
Beale's House, chimney	44 00 41.95	69 03 59.48	64 26 24	False White Head	244 24 44	3546.1	3877.9	2.20
			259 44 49	High Island	79 45 20	1001.7	1095.5	0.62

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and St. George's River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Large House, north chimney	43 59 48.88	69 06 40.49	254 29 24	False White Head	74 29 36	402.8	440.5	0.25
			54 36 57	Norton's Island	234 35 50	2615.7	2860.4	1.63
White Head Island, east chimney of house.	43 58 57.02	69 07 35.82	126 04 55	St. George's Church	306 01 59	6975.7	7628.4	4.33
			65 46 42	Turkey Church	245 42 01	9907.3	10834.3	6.16
Smalley's Hill, flag	43 59 16.25	69 12 42.59	0 23 11	Tenant's Harbor Church	180 23 10	2397.3	2621.6	1.49
			198 46 25	St. George's Church	18 47 02	3709.6	4056.7	2.30
Widow Ellena Hart's House, centre chimney.	43 57 34.30	69 12 09.87	135 09 50	Tenant's Harbor Church	315 09 27	1056.9	1155.7	0.66
			62 34 52	Turkey Church	242 33 21	3294.6	3602.8	2.05
Hart's Neck, flag in tree	43 57 09.75	69 11 29.69	132 34 07	Tenant's Harbor Church	312 33 16	2228.1	2436.6	1.38
			78 45 45	Turkey Church	258 43 46	3895.2	4259.7	2.42
Island, north of Tenant's Harbor light, flag in tree.	43 58 16.07	69 10 42.95	60 01 08	Turkey Church	239 58 37	5613.8	6139.1	3.49
			247 33 40	Norton's Island	67 35 22	3538.3	3869.4	2.20
Seavey's Hill, flag in tree	43 59 09.76	69 11 46.97	273 43 30	Norton's Island	93 45 57	4707.1	5147.6	2.93
			29 45 40	Tenant's Harbor Church	209 45 01	2530.0	2766.7	1.57
Russel's Hill, flag in tree	43 57 35.39	69 14 37.23	346 52 21	Turkey Church	166 52 32	1592.9	1742.0	0.99
			254 15 08	Tenant's Harbor Church	74 16 27	2638.2	2885.1	1.64
Fogg's Hill, No. 1, flag in tree	44 00 26.48	69 07 53.05	297 42 46	False White Head	117 43 49	2263.3	2475.1	1.41
			104 22 47	St. George's Church	284 20 03	5423.3	5930.7	3.37
Fogg's Hill, No. 2, flag in tree	44 00 26.77	69 07 45.75	14 10 18	Norton's Island	194 09 57	2768.5	3027.5	1.72
			299 57 31	False White Head	119 58 28	2125.6	2324.5	1.32
Joseph Clark's House, chimney in centre.	43 57 16.20	69 12 43.25	179 56 35	Tenant's Harbor Church	359 56 35	1307.8	1430.1	0.81
			66 15 22	Turkey Church	246 14 14	2381.9	2604.8	1.48
Enoch Clark's Barn, centre	43 57 05.20	69 12 45.54	239 28 14	Norton's Island	59 31 21	6968.2	7620.2	4.33
			189 27 48	St. George's Church	9 28 27	7661.0	8377.8	4.76
Centre of Barn, near middle peninsula.	44 00 38.69	69 10 27.49	118 03 34	St. George's Church	298 04 37	2057.0	2249.5	1.28
			35 51 12	Turkey Church	215 48 30	8890.9	9722.8	5.52
Post Hill, yellow house chimney	44 05 09.10	69 04 17.55	160 00 13	Bear Hill	339 58 59	6864.7	7507.0	4.27
			82 08 04	Ingraham	262 06 31	3004.4	3285.5	1.87
Flag in tree near Post Hill	44 05 14.20	69 04 04.33	80 08 49	Ingraham	260 07 07	3319.3	3629.9	2.06
			64 39 57	Post Hill	244 39 50	265.8	290.6	0.16
Norton's Island, flag in tree	43 58 54.94	69 08 09.00	133 15 27	Norton's Island	313 15 22	218.9	239.3	0.14
			204 09 47	Post Hill	24 12 30	12706.0	13894.9	7.90
Mosquito Island, flag in tree	43 55 03.11	69 12 52.46	147 53 46	Turkey Church	327 52 45	3715.5	4063.1	2.31
			289 33 29	Metinic	109 37 24	8018.4	8768.7	4.98
Hewett's Island, flag in tree	43 59 34.54	69 03 47.30	99 00 54	False White Head	278 59 06	3513.8	3842.6	2.18
			197 33 22	High Island	17 33 44	2368.9	2590.5	1.47
Rackley's Island, flag in tree	44 00 09.04	69 02 36.89	84 11 15	False White Head	264 08 38	5065.0	5539.0	3.15
			144 26 31	High Island	324 26 04	1467.9	1605.2	0.91
Rackley's Island, third-order signal	43 59 54.35	69 02 45.43	89 17 24	False White Head	269 14 53	4849.2	5303.0	3.01
			158 03 27	High Island	338 03 06	1775.8	1941.9	1.10
Crescent Island, third-order signal	44 01 18.13	69 01 48.11	155 29 05	Post Hill	335 27 23	7883.0	8620.6	4.90
			136 50 34	Ingraham	316 47 17	9211.6	10073.5	5.72
Harrington's Hill, flag in tree	44 01 39.87	69 07 55.66	328 08 04	False White Head	148 09 08	3906.6	4272.1	2.43
			217 01 45	Post Hill	37 04 18	8145.1	8907.3	5.06
Captain Crockett's House, north-east chimney.	43 59 20.87	69 04 05.16	107 33 36	False White Head	287 32 00	3222.9	3524.4	2.00
			202 32 04	High Island	22 32 39	2901.6	3173.0	1.80
Pleasant Island, flag in tree	43 58 57.80	69 05 14.81	137 54 48	False White Head	317 54 01	2269.8	2482.2	1.41
			90 53 10	Norton's Island	270 51 04	4042.1	4420.3	2.51
Thorndike's Hill, flag in tree	44 01 47.23	69 06 39.39	181 45 44	Ingraham	1 45 50	5821.3	6366.0	3.62
			354 09 00	False White Head	174 09 11	3563.7	3897.1	2.21
Fisherman's Island, flag	44 02 30.30	69 01 55.56	147 52 23	Post Hill	327 50 46	5839.6	6386.0	3.63
			29 16 24	High Island	209 15 29	3628.7	3968.2	2.25
Red School-house, chimney	44 04 35.47	69 05 46.00	241 50 44	Post Hill	61 51 47	2292.5	2507.0	1.42
			121 50 37	Ingraham	301 50 06	1187.4	1298.5	0.74
Sheep Island, flag in tree	44 03 48.50	69 02 43.15	7 17 56	High Island	187 17 34	5624.2	6150.5	3.49
			141 02 42	Post Hill	321 01 38	3255.2	3559.8	2.02
Ash Island, white flag in tree	44 02 24.57	69 03 52.76	35 29 37	False White Head	215 27 52	5768.1	6307.9	3.58
			42 53 49	Norton's Island	222 50 46	8623.1	9430.0	5.36
Ash Point, flag in tree	44 02 48.34	69 04 23.81	26 04 17	False White Head	206 02 54	6045.8	6611.5	3.76
			144 11 37	Ingraham	324 10 08	4849.5	5303.3	3.01
Garden Island Ledge, red spindle, with one ball.	44 00 45.85	69 05 25.12	38 02 01	False White Head	218 01 21	2096.0	2292.2	1.30
			268 50 30	High Island	88 52 00	2893.5	3164.2	1.80

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I—Penobscot Bay and St. George's River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Otter Island Ledge, black spindle, with two balls.	44 01 29.24	69 04 30.53	39 59 25	False White Head	219 58 07	3901.9	4267.0	2.42
			307 22 13	High Island	127 23 05	2110.2	2307.6	1.31
Jameson's Point, chimney of white house.	44 06 59.54	69 04 51.06	152 13 09	Bear Hill	332 12 19	3438.6	3760.3	2.14
			247 02 05	Jameson	67 02 10	170.6	186.6	0.11
Rockland Steam Mill, tall chimney	44 06 28.23	69 06 16.97	311 30 33	Post Hill	131 31 58	3618.7	3957.3	2.25
			243 25 41	Jameson	63 26 46	2310.8	2527.0	1.44
First Baptist Church, clock-faced	44 06 49.57	69 06 09.44	258 48 43	Jameson	78 49 43	1935.8	2116.9	1.20
			182 22 41	Bear Hill	2 22 45	3352.5	3666.2	2.08
Methodist Church	44 06 10.11	69 06 19.97	233 15 26	Jameson	53 16 33	2662.6	2911.7	1.65
			184 40 08	Bear Hill	4 40 20	4582.5	5011.2	2.85
Episcopal Church	44 06 06.05	69 06 32.11	234 26 23	Jameson	54 27 38	2954.7	3231.1	1.84
			187 48 13	Bear Hill	7 48 33	4736.5	5179.7	2.94
Baptist Church	44 06 21.16	69 06 14.96	238 13 58	Jameson	58 15 01	2378.2	2600.8	1.48
			7 52 09	Ingraham	187 51 58	2660.5	2909.4	1.65
Congregationalist Church	44 06 22.52	69 06 15.59	7 27 39	Ingraham	187 27 28	2699.9	2952.5	1.68
			183 46 21	Bear Hill	3 46 30	4193.4	4585.8	2.61
Church, cupola	44 07 06.68	69 05 49.73	12 53 52	Ingraham	192 53 23	4145.4	4533.3	2.58
			275 57 24	Jameson	95 58 10	1468.6	1606.0	0.91
White Spire Vane, heart and arrows.	44 06 12.80	69 06 20.34	184 51 38	Bear Hill	4 51 50	4501.2	4922.4	2.80
			304 36 48	Post Hill	124 38 15	3383.8	3700.5	2.10
Roman Catholic Church	44 06 05.77	69 06 42.27	190 28 03	Bear Hill	10 28 30	4781.7	5229.2	2.97
			297 31 00	Post Hill	117 32 43	3690.1	4035.4	2.29
Unpainted House, chimney in centre.	44 02 47.95	69 04 46.36	331 18 59	High Island	151 20 02	4228.9	4624.6	2.63
			188 57 55	Post Hill	8 58 17	4454.2	4871.0	2.77
Dodge Homestead, south chimney	44 08 09.90	69 07 30.15	337 24 24	High Island	157 27 21	14777.9	16160.6	9.18
			245 43 59	Bear Hill	65 45 00	2119.9	2318.2	1.32
Centre of dark barn on hill-side	44 07 10.91	69 07 48.97	307 59 06	Post Hill	128 01 35	6034.7	6599.3	3.75
			273 55 39	Jameson	93 57 48	4121.9	4507.6	2.56
Rockport, Universalist church	44 11 02.79	69 04 11.64	117 22 20	Ragged Mount	297 19 11	6796.4	7432.3	4.22
			29 02 18	Bear Hill	209 01 00	5106.6	5584.4	3.17
Rockport, Congregationalist church, square spire.	44 11 14.78	69 03 46.64	112 41 15	Ragged Mount	292 37 48	7143.2	7811.6	4.44
			32 06 49	Bear Hill	212 05 14	5707.9	6241.9	3.55
Edwin Ojier's House	44 11 53.17	69 03 18.46	102 17 04	Ragged Mount	282 13 17	7385.0	8076.0	4.59
			31 18 24	Bear Hill	211 16 29	7044.5	7703.6	4.38
Raccoon	44 00 31.11	69 16 37.23	259 21 52	St. George's Church	79 25 12	6533.8	7145.2	4.06
			336 27 20	Turkey Church	156 28 55	7606.4	8318.1	4.73
Smith	44 03 15.82	69 14 07.73	33 13 56	Raccoon	213 12 12	6076.0	6644.6	3.78
			321 26 33	St. George's Church	141 28 10	4961.3	5425.5	3.08
Hall	44 02 47.92	69 10 19.12	99 37 34	Smith	279 34 55	5160.8	5643.7	3.21
			33 30 23	St. George's Church	213 29 21	3620.7	3959.5	2.25
Watts	43 59 35.72	69 13 19.35	14 37 05	Turkey Church	194 36 22	5440.8	5949.9	3.38
			214 40 13	St. George's Church	34 41 16	3541.3	3872.6	2.20
Stone	44 02 00.85	69 12 16.93	241 00 04	Hall	61 01 26	2998.1	3278.7	1.86
			338 15 23	St. George's Church	158 15 43	1687.3	1845.2	1.05
Otis	43 58 57.34	69 14 43.22	223 27 49	St. George's Church	43 29 50	5644.8	6172.9	3.51
			138 44 06	Raccoon	318 42 47	3850.3	4210.5	2.39
Recess	44 03 55.75	69 11 31.44	70 30 19	Smith	250 28 30	3690.0	4035.3	2.29
			322 25 58	Hall	142 26 48	2640.7	2887.8	1.64
Rivers's House, north chimney	43 59 50.91	69 15 01.81	240 21 39	St. George's Church	60 23 53	4943.5	5406.0	3.07
			120 16 44	Raccoon	300 15 38	2461.0	2691.3	1.53
South Thomaston, white spire	44 03 08.91	69 06 57.43	189 58 08	Ingraham	9 58 26	3347.3	3660.5	2.08
			202 26 08	Jameson	22 27 41	7774.7	8502.1	4.83
Thomaston, one-story octagonal cupola.	44 04 45.97	69 10 12.87	17 48 35	St. George's Church	197 47 28	6998.4	7653.1	4.35
			266 28 15	Ingraham	86 30 49	4937.6	5399.6	3.07
Thomaston Church, tall spire, with green blinds.	44 04 48.74	69 09 45.76	11 18 06	Hall	191 17 43	3803.3	4159.2	2.36
			63 50 03	Smith	243 47 01	6500.2	7108.4	4.04
Thomaston Church, two-story octagonal spire, with pillars.	44 04 45.43	69 10 15.76	61 50 32	Smith	241 47 51	5860.0	6408.3	3.64
			1 13 34	Hall	181 13 32	3628.8	3968.3	2.25
Thomaston, small church, low spire.	44 04 43.24	69 10 32.98	60 34 30	Smith	240 32 01	5492.1	6006.0	3.41
			355 06 18	Hall	175 06 27	3573.7	3908.0	2.22
Thomaston Church, tall white spire.	44 04 36.07	69 10 38.81	61 58 08	Smith	241 55 43	5271.4	5764.6	3.28
			352 34 15	Hall	172 34 28	3368.0	3683.1	2.09

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Penobscot Bay and St. George's River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Thomaston Church, low spire, with dome roof, clock-face.	44 04 41.28	69 10 44.40	59 47 20	Smith	239 44 58	5241.0	5731.4	3.26
			350 54 46	Hall	170 55 03	3543.8	3875.4	2.20
Thomaston Church	44 04 36.56	69 10 56.87	59 37 01	Smith	239 34 48	4924.1	5384.9	3.06
			345 55 02	Hall	165 55 28	3456.3	3779.7	2.15
Cushing Church, No. 1	43 59 42.75	69 16 37.40	180 02 11	Raccoon	0 02 11	1492.4	1632.0	0.93
			330 59 15	Turkey Church	151 00 50	6268.0	6854.4	3.89
Cushing Church, No. 2	44 00 53.66	69 14 43.10	190 08 39	Smith	10 09 03	4456.0	4873.0	2.77
			74 41 00	Raccoon	254 39 41	2637.9	2884.7	1.64
Brown's Hill	44 04 03.89	69 10 48.63	344 20 50	Hall	164 21 10	2434.9	2662.8	1.51
			75 13 28	Recess	255 12 58	985.3	1077.5	0.61
Farm-house, centre chimney	44 03 52.41	69 09 19.21	33 49 19	Hall	213 48 37	2395.8	2619.9	1.49
			100 06 19	Brown's Hill	280 05 17	2021.2	2210.3	1.26
Fisherman's East Gable	44 03 40.32	69 11 05.24	206 55 06	Brown's Hill	26 55 18	816.0	892.4	0.51
			327 35 36	Hall	147 36 08	1915.5	2094.7	1.19
Burton's Hill	44 01 35.62	69 12 33.51	233 16 20	Hall	53 17 53	3732.4	4081.6	2.32
			308 24 05	St. George's Church	128 24 36	1268.5	1387.2	0.79
Blank Point	44 00 49.68	69 12 31.47	178 09 50	Burton's Hill	358 09 49	1418.5	1551.2	0.88
			236 25 07	St. George's Church	56 25 37	1138.7	1245.2	0.71
Foundation Hill	43 59 40.36	69 13 33.62	110 58 18	Raccoon Point	290 56 10	4379.8	4789.6	2.72
			220 06 25	St. George's Church	40 07 38	3621.4	3960.2	2.25
Fort St. George	44 01 27.68	69 12 06.90	30 15 33	Foundation Hill	210 14 33	3834.2	4193.0	2.38
			112 28 10	Burton's Hill	292 27 52	641.2	701.2	0.40
Narrows	43 59 04.22	69 15 16.03	146 00 16	Raccoon Point	325 59 20	3234.6	3537.2	2.01
			243 56 39	Foundation Hill	63 57 50	2539.8	2777.4	1.58
Stone Point	43 58 18.56	69 16 12.56	172 21 02	Raccoon Point	352 20 45	4127.5	4513.7	2.56
			234 30 15	Foundation Hill	54 32 05	4349.3	4756.3	2.70
J. Stone's House, centre chimney	43 58 16.51	69 16 21.91	175 18 18	Raccoon Point	355 18 07	4167.9	4557.8	2.59
			235 22 38	Foundation Hill	55 24 35	4556.2	4982.5	2.83
Hornbarn Hill	43 58 39.17	69 17 38.94	250 55 16	Foundation Hill	70 58 06	5783.5	6324.6	3.59
			288 16 42	Stone Point	108 17 42	2027.1	2216.8	1.26
Maple Hill	43 58 44.76	69 17 10.21	192 37 07	Raccoon Point	12 37 30	3363.1	3677.8	2.09
			237 54 11	St. George's Church	57 57 54	8447.3	9237.7	5.25
Hathorn Hill	43 58 51.86	69 16 41.66	181 50 49	Raccoon Point	1 50 52	3064.0	3350.7	1.90
			72 58 02	Hornbarn Hill	252 57 22	1335.3	1460.2	0.83
Adam Teal's House, centre chimney	43 58 06.57	69 14 55.50	120 35 36	Hathorn Hill	300 34 22	2747.4	3004.5	1.71
			102 10 03	Stone Point	282 09 09	1757.6	1922.0	1.09
Friendship	43 59 52.39	69 17 50.66	233 50 38	Raccoon Point	53 51 25	2025.7	3215.2	1.26
			336 38 24	Maple Hill	156 38 52	2273.1	2485.8	1.41
J. Seavey's House, centre chimney	43 59 11.75	69 16 20.54	353 49 28	Stone Point	173 49 33	1651.0	1805.5	1.03
			37 26 37	Hathorn Hill	217 26 22	773.4	845.7	0.48
Muscongus Bay, from Penobscot Bay to Damariscotta River.								
Monhegan	43 46 15.39	69 17 56.93	....	....	....	....	....	....
Edgecombe	43 57 12.25	69 35 56.91	309 56 48	Monhegan	130 09 16	31503.3	34451.0	19.57
Turkey Church	43 56 45.12	69 14 21.03	13 57 17	Monhegan	193 54 47	20022.4	21895.9	12.44
			91 47 11	Edgecombe	271 32 12	28906.0	31610.8	17.96
Kenniston	43 53 02.45	69 36 54.29	189 24 59	Edgecombe	9 25 39	7815.1	8546.4	4.86
			296 11 30	Monhegan	116 24 55	28345.9	30998.2	17.62
Damiscove	43 45 15.64	69 36 26.24	177 30 42	Kenniston	357 30 22	14419.0	15768.1	8.96
			265 38 18	Monhegan	85 51 26	24879.8	27207.8	15.46
Parker's Island	43 49 21.49	69 43 40.90	233 03 22	Kenniston	53 08 10	11355.5	12418.0	7.06
			307 56 20	Damiscove	128 01 20	12327.9	13481.4	7.66
Pemmaquid	43 51 44.94	69 29 57.32	302 12 43	Monhegan	122 21 02	19041.5	20823.2	11.83
			245 59 49	Turkey Church	66 10 38	22854.0	24992.5	14.20
White Island	43 47 13.33	69 34 05.71	274 37 31	Monhegan	94 48 41	21735.9	23769.7	13.51
			213 29 09	Pemmaquid	33 32 01	10052.3	10992.9	6.25
Davis	43 54 31.37	69 22 40.31	62 16 23	Pemmaquid	242 11 20	11023.9	12055.4	6.85
			48 37 11	White Island	228 29 16	20421.3	22332.1	12.69
Johnston	44 00 48.60	69 25 27.56	64 36 32	Edgecombe	244 29 15	15530.7	16983.9	9.65
			342 13 30	Davis	162 15 26	12224.8	13368.6	7.60
Blin	44 07 13.33	69 40 30.64	300 29 24	Johnston	120 39 52	23341.1	25525.1	14.51
			341 47 02	Edgecombe	161 50 12	19523.8	21350.7	12.13

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Muscongus Bay.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Gull	43 52 39.19	69 24 37.35	76 50 32	Pemmaquid	256 46 50	7337.1	8023.7	4.56
			217 01 29	Davis	37 02 50	4337.0	4742.8	2.69
Reed	43 49 28.12	69 34 25.88	353 48 43	White Island	173 48 57	4183.8	4575.3	2.60
			153 24 24	Kenniston	333 22 41	7398.7	8091.0	4.60
Auld	43 53 11.80	69 35 11.25	290 53 58	Pemmaquid	110 57 36	7503.1	8205.2	4.66
			82 51 51	Kenniston	262 50 40	2317.1	2533.9	1.44
Caldwell	43 56 14.93	69 17 21.84	256 58 16	Turkey Church	77 00 21	4139.2	4526.5	2.57
			65 48 22	Davis	245 44 41	7789.2	8518.1	4.84
Muscongus	43 58 41.69	69 26 23.46	197 37 47	Johnston	17 38 26	4110.0	4494.6	2.55
			327 11 32	Davis	147 14 07	9189.2	10049.1	5.71
Dodge	43 55 33.46	69 35 46.09	18 04 22	Kenniston	198 03 35	4901.1	5359.7	3.05
			175 28 56	Edgecombe	355 28 49	3059.5	3345.8	1.90
Captain Childs's Cupola	43 53 01.77	69 31 03.83	26 37 38	Damiscove	206 33 55	16086.4	17591.6	9.99
			20 42 46	White Island	200 40 40	11494.4	12569.9	7.14
Square House	43 53 17.45	69 29 45.13	131 11 20	Edgecombe	311 07 02	11013.4	12043.9	6.84
			5 26 09	Pemmaquid	185 26 01	2867.3	3135.6	1.78
Muscongus Island, white chimney	43 55 14.40	69 25 11.74	44 37 14	Pemmaquid	224 33 56	9077.3	9926.7	5.64
			350 53 58	Gull	170 54 22	4850.5	5304.3	3.01
Cranberry Island, chimney	43 56 16.40	69 20 47.54	37 49 18	Davis	217 48 00	4102.8	4486.7	2.55
			120 56 42	Muscongus	300 52 49	8728.4	9545.1	5.42
Cranberry, signal	43 56 03.38	69 21 22.50	55 16 43	Pemmaquid	235 10 46	13985.0	15293.6	8.69
			31 26 52	Davis	211 25 58	3328.0	3639.3	2.07
Carter's Island, tree	43 53 46.50	69 25 48.06	322 46 13	Gull	142 47 02	2609.1	2853.3	1.62
			56 02 02	Pemmaquid	235 59 09	6710.6	7338.6	4.17
Crow	43 55 32.73	69 22 06.37	99 30 09	Edgecombe	279 20 33	18773.1	20529.7	11.66
			155 19 02	Johnston	335 16 42	10729.8	11733.8	6.67
Marsh	43 54 37.28	69 23 40.44	57 44 00	Pemmaquid	237 39 39	9952.5	10883.7	6.18
			277 43 16	Davis	97 43 58	1354.4	1481.1	0.84
Otter Island, chimney	43 55 59.15	69 20 14.09	58 58 35	Pemmaquid	238 51 51	15196.3	16618.2	9.44
			50 18 09	Davis	230 16 28	4239.6	4636.3	2.63
Franklin Light	43 53 30.81	69 22 09.64	72 40 02	Pemmaquid	252 34 38	10939.8	11963.4	6.80
			337 10 53	Monhegan	157 13 48	14574.5	15938.2	9.06
Thompson	43 53 57.56	69 18 47.07	228 54 24	Turkey Church	48 57 29	7871.9	8608.5	4.89
			75 45 51	Pemmaquid	254 38 06	15509.7	16960.9	9.64
Barn on Davis Island, west gable	43 53 21.26	69 17 58.57	79 34 25	Pemmaquid	259 26 07	16317.6	17844.4	10.14
			81 44 28	Gull	261 39 52	8995.6	9837.3	5.59
Harbor	43 52 36.17	69 18 04.09	84 24 02	Pemmaquid	264 15 48	16000.9	17498.1	9.94
			65 12 49	White Island	245 01 43	23680.6	25896.4	14.71
Allen	43 52 13.88	69 18 23.20	86 46 07	Pemmaquid	266 38 06	15523.3	16975.8	9.65
			126 30 17	Davis	306 27 19	7136.1	7803.9	4.43
Burnt Island	43 51 59.01	69 17 21.97	88 35 58	Pemmaquid	268 27 15	16870.8	18449.4	10.48
			123 31 35	Davis	303 27 49	8519.4	9316.6	5.29
Monhegan Fog-bell	43 45 46.43	69 19 16.41	127 44 47	Pemmaquid	307 37 23	18098.0	19791.4	11.24
			164 18 58	Davis	344 16 37	16827.9	18402.4	10.46
Thrumbcap	43 49 16.55	69 32 37.37	34 33 37	Damiscove	214 30 59	9024.9	9869.4	5.61
			27 27 10	White Island	207 26 09	4284.5	4685.4	2.66
Damiscove, white flag	43 46 32.59	69 36 13.42	246 13 40	White Island	66 15 08	3119.5	3411.4	1.94
			221 02 38	Pemmaquid	41 06 58	12788.8	13985.4	7.95
Rutherford's Island	43 51 15.88	69 33 02.11	122 25 04	Kenniston	302 22 23	6138.1	6712.5	3.81
			10 45 26	White Island	190 44 42	7617.8	8330.6	4.73
Hodgden's Mills, chimney	43 52 01.67	69 34 50.00	274 29 09	Pemmaquid	94 32 32	6555.1	7168.5	4.07
			124 04 33	Kenniston	304 03 07	3348.3	3661.6	2.08
Bristol, red flag	43 52 01.70	69 33 14.22	110 54 54	Kenniston	290 52 22	5256.9	5748.8	3.27
			276 41 10	Pemmaquid	96 43 26	4425.9	4840.1	2.75
John's Island, flag	43 51 57.35	69 31 43.17	279 11 19	Pemmaquid	99 12 32	2394.0	2618.0	1.49
			19 59 06	White Island	199 57 27	9324.9	10197.5	5.79
Pemmaquid Point, chimney of house.	43 51 02.02	69 29 13.29	233 35 45	Davis	53 40 17	10894.1	11913.5	6.77
			300 16 05	Monhegan	120 23 53	17512.4	19151.0	10.88
House with red chimney	43 54 59.13	69 25 53.96	326 33 31	Monhegan	146 39 01	19358.7	21170.1	12.02
			338 24 14	Gull	158 25 07	4644.4	5079.0	2.89
McGee	43 54 46.82	69 18 29.59	85 09 24	Davis	265 06 30	5614.3	6139.6	3.49
			236 36 44	Turkey Church	56 39 36	6640.1	7261.4	4.13

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Muscongus Bay.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Church at Herring Gut	43 55 42.70	69 14 59.55	12 45 51 77 57 28	Monhegan Davis	192 43 48 257 52 09	17949.4 10511.7	19628.9 11495.3	11.15 6.53
Edgecombe, tall tree	43 57 35.54	69 36 59.11	297 20 31 359 15 34	Edgecombe Kenniston	117 21 14 179 15 37	1561.5 8427.8	1707.6 9216.4	0.97 5.24
White Chimney of large house	43 55 48.94	69 33 06.79	29 48 27 44 40 18	Auld Kenniston	209 47 01 224 37 40	5588.1 7221.6	6111.0 7897.3	3.47 4.49
Sproul	43 54 35.31	69 33 16.69	59 28 21 44 46 28	Kenniston Auld	239 25 50 224 45 09	5637.6 3630.0	6165.1 3969.7	3.50 2.26
Clark's Barn	43 54 27.65	69 32 48.66	64 23 49 140 27 22	Kenniston Edgecombe	244 20 59 320 25 11	6078.0 6591.0	6646.7 7207.7	3.78 4.09
Luther Davis' House	43 51 57.98	69 29 55.46	102 03 13 243 58 20	Kenniston Davis	281 58 23 64 03 22	9558.3 10804.4	10452.7 11815.4	5.94 6.71
Barn, north gable	43 50 41.81	69 30 01.17	40 22 16 115 14 23	White Island Kenniston	220 19 27 295 09 37	8440.3 10193.4	9230.0 11147.2	5.24 6.33
White Spire of church at Round Pond.	43 56 47.51	69 27 24.00	200 56 48 303 33 23	Muscongus Davis	20 57 30 123 36 40	3773.4 7595.1	4126.5 8305.8	2.34 4.72
Brown Spire of church at Round Pond.	43 56 48.77	69 27 20.01	199 52 46 304 10 40	Muscongus Davis	19 53 25 124 13 54	3705.8 7543.1	4052.5 8248.9	2.30 4.69
Chimney of large unpainted house	43 56 16.60	69 25 24.30	163 35 36 311 35 03	Muscongus Davis	343 34 55 131 36 57	4667.7 4891.6	5104.4 5349.3	2.90 3.04
White House with red roof, chimney	43 56 09.24	69 25 19.51	178 48 47 163 08 36	Johnston Muscongus	358 48 41 343 07 52	8622.9 4916.2	9429.8 5376.2	5.36 3.05
Hog Island	43 57 56.30	69 25 12.35	131 28 54 176 20 55	Muscongus Johnston	311 28 05 356 20 44	2115.5 5328.2	2313.4 5826.8	1.31 3.31
Greenland Cove, south chimney of White House.	43 59 48.88	69 25 20.47	339 57 42 34 05 59	Davis Muscongus	159 59 33 214 05 15	10429.0 2503.8	11404.8 2738.1	6.48 1.56
Oar	43 59 08.36	69 24 10.40	346 46 02 74 30 04	Davis Muscongus	166 47 05 254 28 32	8781.0 3077.2	9602.6 3365.2	5.46 1.91
Pine	44 00 39.48	69 23 41.49	353 09 11 44 48 04	Davis Muscongus	173 09 53 224 46 12	11441.9 5121.2	12512.5 5600.4	7.11 3.18
Cow	43 57 40.51	69 23 11.21	152 23 29 353 16 54	Johnston Davis	332 21 54 173 16 33	6551.2 5876.8	7164.2 6426.7	4.07 3.65
Long Island	43 59 06.71	69 23 04.18	134 34 27 356 25 09	Johnston Davis	314 32 47 176 25 26	4481.6 8514.2	4900.9 9310.9	2.78 5.29
Hungry	44 00 21.05	69 21 57.80	100 19 54 62 37 00	Johnston Muscongus	280 17 28 242 33 55	4748.7 6667.6	5193.0 7291.5	2.95 4.14
Otter	43 55 30.14	69 20 30.03	146 01 24 126 54 25	Johnston Muscongus	325 57 57 306 50 20	11856.1 9850.6	12965.5 10772.4	7.37 6.12
Lobster	43 54 40.65	69 22 06.62	158 29 43 142 25 48	Johnston Muscongus	338 27 23 322 22 50	12207.1 9387.8	13349.3 10266.2	7.58 5.83
Waldoboro', church spire, No. 1	44 02 28.30	69 19 28.73	66 12 09 68 58 21	Edgecombe Johnston	246 00 43 248 54 12	24076.3 8561.6	26329.1 9362.6	14.96 5.32
Hooper	43 55 21.05	69 15 52.91	218 18 36 129 59 18	Turkey Church Caldwell	38 19 40 309 58 16	3307.1 2587.9	3616.6 2830.0	2.05 1.61
Long White House, chimney in centre.	44 01 04.42	69 19 49.94	86 18 59 63 21 40	Johnston Muscongus	266 15 04 243 17 06	7535.1 9810.8	8240.2 10728.8	4.68 6.10
Stahl	44 02 44.29	69 22 13.17	50 29 57 355 34 15	Johnston Hungry	230 27 42 175 34 26	5610.7 4433.6	6135.7 4848.4	3.49 2.76
Church	44 02 27.19	69 19 29.51	98 15 32 40 19 21	Stahl Hungry	278 13 38 220 17 38	3681.2 5104.5	4025.6 5582.1	2.29 3.17
Comery	44 04 42.81	69 21 50.38	7 53 53 323 09 10	Stahl Church	187 53 37 143 10 48	3692.6 5229.2	4038.1 5718.5	2.29 3.25
Geel	44 03 42.41	69 22 59.60	330 02 52 219 33 41	Stahl Comery	150 03 24 39 34 29	2070.0 2418.0	2263.7 2644.2	1.29 1.50
Kinsel	44 05 05.38	69 23 02.02	358 47 47 293 36 19	Geel Comery	178 47 49 113 37 09	2561.2 1739.4	2800.8 1902.2	1.59 1.08
Burns	44 01 35.59	69 21 03.95	143 59 42 232 51 31	Stahl Church	323 58 54 52 52 37	2621.1 2637.5	2866.3 2884.3	1.63 1.64
Bremo	44 01 44.88	69 22 18.78	67 34 04 250 52 14	Johnston Church	247 31 53 70 54 12	4548.6 3988.4	4974.2 4361.6	2.83 2.48
Red-roofed House, south chimney	44 02 17.56	69 24 34.50	267 27 55 201 39 43	Church Kinsel	87 31 27 21 40 47	6796.1 5572.9	7432.0 6094.4	4.22 3.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Muscongus bay, Damariscotta, Kennebec, and Androscoggin Rivers.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Square Yellow House, chimney	44 03 00.37	69 20 32.02	77 34 45	Stahl	257 33 35	2305.5	2521.2	1.43
			306 20 48	Church	126 21 31	1727.7	1889.3	1.07
One-story White House, chimney	44 03 58.64	69 20 28.93	81 31 12	Geel	261 29 27	3390.2	3707.4	2.11
			334 53 13	Church	154 53 54	3116.7	3408.3	1.94
Waldoboro' Church, cupola	44 05 50.92	69 22 11.18	38 49 13	Kinsel	218 48 38	1803.9	1972.7	1.12
			347 34 59	Comery	167 35 13	2152.4	2353.8	1.34
Waldoboro', short spire	44 05 34.18	69 22 07.32	53 51 17	Kinsel	233 50 39	1506.8	1647.7	0.94
			18 38 18	Geel	198 37 42	3640.4	3981.0	2.26
Waldoboro', tall white spire	44 05 44.82	69 22 06.50	45 24 59	Kinsel	225 24 20	1734.0	1896.3	1.08
			17 22 24	Geel	197 21 47	3957.8	4328.1	2.46
Damariscotta Ri.cr.								
Edgecombe	43 57 12.25	69 35 56.91						
Haggett, 1	43 59 44.31	69 36 18.62	354 06 35	Edgecombe	174 06 50	4717.0	5158.4	2.93
Norwood	43 59 52.85	69 33 34.78	85 52 44	Haggett, 1	265 50 50	3659.7	4002.1	2.27
			32 35 50	Edgecombe	212 34 11	5881.9	6432.3	3.65
Nichols	43 58 18.72	69 33 01.82	165 48 56	Norwood	345 48 33	2996.4	3276.8	1.86
			62 17 36	Edgecombe	242 15 35	4409.1	4821.7	2.74
Ariss	43 59 14.47	69 32 19.20	125 07 32	Norwood	305 06 40	2058.6	2251.2	1.28
			28 54 02	Nichols	208 53 32	1965.5	2149.4	1.22
Hitchcock	44 00 45.52	69 31 37.64	18 14 26	Ariss	198 13 57	2958.4	3235.2	1.84
			58 05 22	Norwood	238 04 01	3074.1	3361.8	1.91
White	44 00 46.95	69 32 58.25	271 24 22	Hitchcock	91 25 18	1795.8	1963.8	1.12
			343 02 45	Ariss	163 03 12	2983.7	3262.8	1.85
Harrington's House, chimney	43 58 34.22	69 34 22.38	284 55 06	Nichols	104 56 02	1858.0	2031.8	1.15
			245 38 17	Ariss	65 39 43	3012.8	3294.7	1.87
Beech	43 56 52.85	69 34 02.63	103 14 02	Edgecombe	283 12 43	2617.3	2862.2	1.63
			207 05 15	Nichols	27 05 57	2976.5	3255.0	1.85
Small Yellow House, chimney in centre.	44 00 04.20	69 31 37.65	31 06 48	Ariss	211 06 19	1792.1	1959.8	1.11
			180 01 07	Hitchcock	0 01 07	1274.9	1394.2	0.79
School-house, cupola	42 02 18.92	69 32 03.15	348 50 24	Hitchcock	168 50 41	2937.0	3211.9	1.83
			3 35 55	Ariss	183 35 44	5704.3	6238.0	3.54
Damariscotta, white spire	44 01 52.82	69 31 25.65	37 51 00	Norwood	217 49 30	4688.6	5127.3	2.91
			7 18 58	Hitchcock	187 18 50	2094.0	2290.0	1.30
Damariscotta, brown spire	44 01 58.88	69 31 14.09	46 16 02	White	226 14 50	3210.6	3511.1	1.99
			13 02 22	Hitchcock	193 02 06	2323.8	2541.3	1.44
Newcastle, church, brown cupola	44 02 03.38	69 31 54.84	30 54 44	White	210 54 00	2749.0	3006.2	1.71
			350 55 19	Hitchcock	170 55 31	2432.2	2659.8	1.51
Kennebec and Androscoggin Rivers.								
Sprague	43 58 30.46	69 53 43.41						
Hodgkin	43 58 42.03	69 48 26.67		Sprague	267 04 28	7067.9	7729.2	4.39
Brunswick, Congregat'list church spire.	43 54 37.24	69 57 26.98	214 40 48	Sprague	34 43 23	8755.1	9574.3	5.44
			237 51 30	Hodgkin	57 57 44	14220.2	15550.8	8.84
Maxwell	44 02 11.55	69 50 14.17	34 21 29	Sprague	214 19 04	8262.9	9036.1	5.13
			339 40 08	Hodgkin	159 41 23	6895.0	7540.2	4.28
Hathorn	44 01 47.74	69 47 34.28	101 40 28	Maxwell	281 38 37	3634.8	3974.9	2.26
			53 31 06	Sprague	233 26 50	10231.4	11188.7	6.36
Bowdoinham, brown spire	44 00 30.75	69 53 38.53	1 40 48	Sprague	181 40 45	3713.7	4061.1	2.31
			295 44 42	Hodgkin	115 48 19	7715.7	8437.6	4.79
Bowdoinham, white spire	44 00 34.19	69 53 36.63	2 16 10	Sprague	182 16 05	3821.3	4178.8	2.37
			296 35 32	Hodgkin	116 39 07	7724.5	8447.3	4.80
Buckner	43 57 10.73	69 51 14.05	60 22 19	Brunswick, church	240 18 00	9571.3	10466.7	5.95
			126 28 49	Sprague	306 27 05	4140.4	4527.8	2.57
Hunter	43 55 55.53	69 53 56.68	183 32 14	Sprague	3 32 23	4790.7	5239.0	2.98
			237 22 07	Buckner	57 24 04	4305.6	4708.4	2.68
Brunswick, tall tree	43 55 07.18	69 53 35.12	178 18 44	Sprague	358 18 38	6276.2	6863.5	3.90
			162 08 12	Hunter	342 07 57	1567.4	1714.1	0.97
Foster	43 55 12.52	69 55 15.26	274 12 18	Brunswick, tall tree	94 13 28	2239.9	2449.5	1.39
			232 51 35	Hunter	52 52 29	2198.6	2404.3	1.37

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Kennebec and Androscoggin Rivers and Boston Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
House, chimney in centre	43 58 58.13	69 51 36.66	225 51 38	Hathorn	45 54 26	7519.7	8223.3	4.67
			351 20 57	Buckner	171 21 13	3352.7	3666.5	2.08
East Telegraph Pole	43 57 04.34	69 48 31.69	73 41 31	Hunter	253 37 46	7550.7	8257.2	4.69
			166 27 45	Maxwell	346 26 34	9752.5	10665.0	6.06
West Telegraph Pole	43 56 57.90	69 48 45.08	74 32 20	Hunter	251 28 44	7209.1	7883.7	4.48
			168 24 51	Maxwell	348 23 49	9881.5	10806.1	6.14
Boston Harbor.								
Powderhorn	42 24 02.71	71 01 30.95	....	....	....	....	....	.....
Nantasket	42 18 13.69	70 53 59.10	136 12 09	Powderhorn	316 07 05	14929.1	16326.1	9.28
Corey	42 20 31.38	71 07 41.18	232 22 35	Powderhorn	52 26 44	10688.9	11689.0	6.63
Boston State House	42 21 27.61	71 03 30.00	209 37 50	Powderhorn	29 39 10	5505.9	6021.1	3.42
			73 13 51	Corey	253 11 02	6004.5	6566.3	3.73
Nahant, 1860	42 25 02.83	70 53 57.24	79 54 21	Powderhorn	259 49 15	10538.2	11524.3	6.55
			0 11 35	Nantasket	180 11 34	12622.8	13804.0	7.84
Moon Head, 1860	42 18 20.05	70 59 02.07	162 09 02	Powderhorn	342 07 22	11107.6	12146.9	6.90
			271 35 20	Nantasket	91 38 44	6941.2	7590.7	4.31
South Pettick's Island	42 17 21.83	70 56 30.63	117 22 27	Moon Head, 1860	297 20 45	3903.5	4268.7	2.43
			193 50 18	Nahant, 1860	13 52 01	14652.0	16023.0	9.10
North Pettick's Island, 1860	42 18 04.33	70 55 26.65	143 01 01	Powderhorn	322 56 56	13848.0	15143.7	8.60
			95 37 59	Moon Head, 1860	275 35 34	4957.4	5421.3	3.08
Point Allerton Beacon, 1860	42 18 45.09	70 52 39.19	128 53 44	Powderhorn	308 47 46	15623.7	17085.6	9.71
			85 00 02	Moon Head, 1860	264 55 44	8801.9	9625.5	5.47
Rainsford Island, flag, 1860	42 18 44.92	70 56 46.05	146 24 17	Powderhorn	326 21 05	11774.5	12876.2	7.32
			76 10 20	Moon Head, 1860	256 08 48	3208.1	3508.3	1.99
Outer Brewster, 1860	42 20 27.35	70 52 20.11	165 21 30	Nahant, 1860	345 20 25	8784.9	9606.9	5.46
			117 51 08	Powderhorn	297 44 56	14246.6	15579.6	8.85
Great Brewster, 1860	42 19 59.70	70 53 24.13	175 22 23	Nahant, 1860	355 22 01	9383.0	10261.0	5.83
			123 59 32	Powderhorn	303 54 04	13426.6	14682.9	8.34
Gallop Island, 1860	42 19 35.98	70 56 02.07	60 24 09	Moon Head, 1860	240 22 08	4740.8	5184.4	2.95
			312 01 31	Nantasket	132 02 54	3791.2	4145.9	2.36
Fawn Beacon	42 21 15.60	70 56 11.82	331 33 26	Nantasket	151 34 55	6381.7	6978.9	3.96
			203 41 28	Nahant, 1860	23 42 59	7656.6	8373.0	4.76
South end of Long Island, 1860	42 18 37.61	70 58 15.83	206 26 24	Nahant, 1860	26 29 19	13276.1	14518.4	8.25
			156 01 12	Powderhorn	335 59 01	10979.3	12006.7	6.82
Winthrop Head	42 22 02.09	70 57 44.98	223 01 26	Nahant, 1860	43 03 59	7630.3	8344.2	4.74
			125 46 31	Powderhorn	305 43 59	6369.3	6965.3	3.96
Hospital on Deer Island, cupola	42 21 10.41	70 57 32.09	214 24 05	Nahant, 1860	34 26 30	8693.0	9506.4	5.40
			134 14 03	Powderhorn	314 11 22	7623.7	8337.0	4.74
Hotel on Long Island, cupola	42 19 25.41	70 57 32.33	205 16 43	Nahant, 1860	25 19 08	11514.7	12592.0	7.15
			147 28 36	Powderhorn	327 25 55	10149.5	11099.2	6.31
Thompson's Island, flag, 1860	42 19 05.88	71 00 04.59	280 51 18	Nantasket	100 55 24	8522.8	9320.3	5.30
			167 49 46	Powderhorn	347 48 48	9368.9	10245.5	5.82
Farm School-house, southeast gable, 1860.	42 19 03.26	71 00 06.50	280 16 05	Nantasket	100 20 12	8551.0	9351.1	5.31
			168 11 31	Powderhorn	348 10 34	9438.8	10322.0	5.86
House in Fort Warren, west gable	42 19 11.11	70 55 21.30	313 15 02	Nantasket	133 15 57	2584.7	2826.5	1.61
			72 42 43	Moon Head, 1860	252 40 14	5295.0	5790.5	3.29
Calf Island, chimney of Weeks's house.	42 20 19.23	70 53 27.93	64 21 38	Moon Head, 1860	244 17 53	8488.1	9282.4	5.27
			10 26 41	Nantasket	190 26 20	3938.1	4306.6	2.45
Weeks's Barn, chimney in middle	42 20 21.50	70 53 31.77	63 40 22	Moon Head, 1860	243 36 40	8439.8	9229.5	5.24
			9 01 17	Nantasket	189 00 59	3992.3	4365.8	2.48
Hull, cupola of Oregon House	42 18 10.15	70 54 26.36	182 59 33	Nahant, 1860	2 59 53	12749.7	13942.6	7.92
			138 15 56	Powderhorn	318 11 10	14585.6	15950.3	9.06
Hull, cupola of Steamboat hotel	42 18 14.27	70 54 47.20	139 21 33	Powderhorn	319 17 01	14175.6	15502.0	8.81
			91 46 23	Moon Head, 1860	271 43 32	5839.7	6386.1	3.63
Kimbal's House, chimney in centre	42 20 17.13	70 53 05.65	121 05 48	Powderhorn	301 00 07	13493.8	14756.5	8.39
			17 49 06	Nantasket	197 48 30	4000.1	4374.4	2.49
Mount Auburn	42 22 08.95	71 08 19.36	249 22 10	Powderhorn	69 26 45	9978.9	10912.6	6.20
			343 48 50	Corey	163 49 16	3134.6	3427.9	1.95
Ten-Hill Farm	42 23 48.51	71 04 54.41	264 35 58	Powderhorn	84 38 15	4673.2	5110.5	2.90
			32 07 03	Corey	212 05 11	7179.6	7851.4	4.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Boston Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Tufts	42 24 24.87	71 06 52.85	292 29 24 275 16 30	Ten-Hill Farm Powderhorn	112 30 44 95 20 07	2931.4 7392.2	3205.7 8083.9	1.82 4.59
Blind Asylum, cupola	42 20 05.05	71 02 11.80	96 10 56 114 28 32	Corey Mount Auburn	276 07 14 294 24 24	7583.0 9239.4	8292.6 10103.9	4.71 5.74
South Bay Tripod	42 19 29.09	71 03 25.53	178 24 05 108 12 11	State House Corey	358 24 02 288 09 19	3657.9 6159.7	4000.1 6736.1	2.27 3.83
East Boston Reservoir	42 22 50.78	71 01 48.77	112 46 22 190 24 17	Ten-Hill Farm Powderhorn	292 44 17 10 24 29	4604.1 2256.2	5034.9 2467.3	2.86 1.40
South Boston Point	42 20 11.03	71 01 12.38	126 53 19 82 16 40	State House Blind Asylum	306 51 46 262 16 00	3937.1 1372.5	4305.5 1500.9	2.45 0.85
Governor's Island, 2	42 21 07.11	71 00 21.79	52 45 09 163 43 43	Blind Asylum Powderhorn	232 43 55 343 42 56	3163.3 5643.9	3459.3 6172.0	1.97 3.51
Lincoln's Wharf	42 21 55.75	71 02 37.12	350 22 33 201 07 26	Blind Asylum Powderhorn	170 22 50 21 08 11	3464.1 4199.3	3788.2 4592.3	2.15 2.61
Eastern Avenue Wharf	42 21 48.12	71 02 35.12	350 28 09 199 27 38	Blind Asylum Powderhorn	170 28 25 19 28 21	3224.7 4404.3	3526.4 4816.4	2.00 2.74
Long Wharf	42 21 34.46	71 02 32.49	350 15 34 197 06 02	Blind Asylum Powderhorn	170 15 48 17 06 43	2799.1 4785.6	3061.1 5233.4	1.74 2.97
Foster's Wharf	42 21 19.17	71 02 40.30	344 04 31 276 40 42	Blind Asylum Governor's Island, 2	164 04 50 96 42 15	2378.2 3191.4	2600.8 3490.0	1.48 1.98
Loring's Machine Shop Wharf	42 20 29.61	71 01 41.64	42 19 53 237 39 13	Blind Asylum Governor's Island, 2	222 19 33 57 40 07	1025.2 2163.1	1121.1 2365.5	0.64 1.34
South Boston Reservoir	42 19 56.52	71 02 25.48	188 52 36 229 58 49	East Boston Reservoir Blind Asylum	8 53 01 49 58 58	5441.0 409.0	5950.1 447.2	3.38 0.25
Boston Neck, dark spire	42 20 24.74	71 04 04.19	332 43 16 92 23 06	South Bay Tripod Corey	152 43 42 272 20 40	1931.4 4970.8	2112.1 5435.9	1.20 3.09
Catholic Cathedral, statue	42 20 10.68	71 04 04.10	273 51 20 325 27 26	Blind Asylum South Bay Tripod	93 52 36 145 27 52	2576.3 1557.4	2817.4 1703.1	1.60 0.97
Berkley Street, yellow spire	42 20 42.15	71 03 54.37	343 40 04 86 21 42	South Bay Tripod Corey	163 40 23 266 19 09	2348.6 5201.7	2568.3 5688.5	1.46 3.24
Roxbury Oil Works	42 19 53.41	71 03 34.09	259 11 57 345 20 57	Blind Asylum South Bay Tripod	79 12 52 165 21 03	1917.5 775.3	2096.9 847.8	1.19 0.48
Machine Shop, tall chimney on ridge pole.	42 20 26.61	71 03 38.04	288 37 07 350 49 36	Blind Asylum South Bay Tripod	108 38 05 170 49 44	2083.1 1797.5	2278.0 1965.7	1.29 1.11
Gas Works, ventilator	42 20 48.29	71 03 06.13	10 18 09 261 12 19	South Bay Tripod Governor's Island, 2	190 17 56 81 14 10	2483.5 3805.3	2715.9 4161.4	1.54 2.37
South Boston, cross on dark spire, with turrets.	42 20 29.88	71 03 03.39	302 58 33 15 07 05	Blind Asylum South Bay Tripod	122 59 08 195 06 50	1407.5 1942.8	1539.2 2124.6	0.87 1.21
Fulton Wire Works, south chimney	42 20 06.04	71 03 08.51	271 21 08 18 52 14	Blind Asylum South Bay Tripod	91 21 46 198 52 03	1298.3 1204.6	1419.8 1317.3	8.80 0.75
Lawrence School, cupola	42 20 26.79	71 02 51.83	23 26 04 250 03 54	South Bay Tripod Governor's Island, 2	203 25 41 70 05 35	1939.9 3652.1	2121.4 3993.8	1.20 2.27
Flagstaff, corner of Dorchester street and turnpike.	42 19 45.61	71 03 05.44	42 03 48 102 38 15	South Bay Tripod Corey	222 03 34 282 35 09	686.2 6467.9	750.4 7073.1	0.42 4.02
Suffolk Cordage Factory, ball	42 19 36.04	71 03 59.20	249 59 20 285 31 59	Blind Asylum South Bay Tripod	70 00 32 105 32 22	2616.2 800.1	2861.0 875.0	1.63 0.50
Prentice's Coal Wharf, post	42 21 06.77	71 02 50.53	269 48 25 335 02 00	Governor's Island, 2 Blind Asylum	89 50 05 155 02 26	3403.9 2100.7	3722.4 2297.3	2.12 1.31
Railroad Tripod	42 20 50.38	71 02 36.77	296 55 23 260 29 56	Loring's Wharf Governor's Island, 2	116 56 00 80 31 27	1415.1 3131.7	1547.5 3424.8	0.88 1.95
Sailors' Home, cupola	42 21 17.12	71 02 47.34	275 16 48 339 54 10	Governor's Island, 2 Blind Asylum	95 18 26 159 54 34	3345.0 2367.8	3658.0 2589.3	2.08 1.47
Roylston School, cupola	42 21 19.53	71 02 47.98	276 30 57 340 10 54	Governor's Island, 2 Blind Asylum	96 32 35 160 11 18	3367.1 2442.6	3682.2 2671.1	2.09 1.52
Fort Hill Wharf, post	42 21 13.77	71 02 44.11	273 35 33 340 46 01	Governor's Island, 2 Blind Asylum	93 37 09 160 46 23	3263.4 2245.6	5568.7 2455.7	2.03 1.40
Central Wharf, cupola	42 21 30.56	71 02 44.15	282 30 19 344 19 16	Governor's Island, 2 Blind Asylum	102 31 55 164 19 38	3337.0 2740.3	3649.2 2996.7	2.07 1.70
India Wharf, cupola	42 21 27.11	71 02 38.65	281 07 48 346 21 09	Governor's Island, 2 Blind Asylum	101 09 20 166 21 27	3192.0 2605.5	3490.7 2849.3	1.98 1.62
India Wharf, post	42 21 26.05	71 02 38.03	280 36 02 346 29 18	Governor's Island, 2 Blind Asylum	100 37 34 166 29 36	3171.9 2570.4	3468.7 2810.9	1.97 1.60

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Boston Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Lewis's Wharf, cupola	42 21 45.45	71 02 38.96	290 38 05	Governor's Island, 2	110 39 37	3354.1	3668.0	2.09
			348 39 08	Blind Asylum	168 39 26	3159.5	3455.1	1.96
James & Pope's Timber Dock, post	42 20 30.52	71 02 18.63	271 53 24	Loring's Wharf	91 53 49	847.0	926.2	0.52
			348 45 15	Blind Asylum	168 45 20	801.3	876.3	0.50
Cunard Wharf, pole	42 21 48.38	71 02 07.99	337 01 57	South Boston Point	157 02 34	3262.0	3567.2	2.03
			297 38 42	Governor's Island, 2	117 39 54	2743.2	2999.9	1.70
Grand Junction Wharf, shears	42 21 45.41	71 02 01.87	297 16 57	Governor's Island, 2	117 18 04	2576.9	2818.0	1.60
			4 11 49	Blind Asylum	184 11 42	3105.0	3395.6	1.93
Bay State Steam Engine Works, wharf post.	42 21 43.54	71 01 48.63	299 28 43	Governor's Island, 2	119 29 41	2282.8	2496.4	1.42
			9 53 56	Blind Asylum	189 53 40	3084.6	3373.2	1.92
Adams school, flagstaff	42 21 55.87	71 01 38.01	310 46 11	Governor's Island, 2	130 47 02	2303.2	2518.7	1.43
			12 44 40	Blind Asylum	192 44 17	3505.6	3833.6	2.18
Dry Dock, post	42 21 42.78	71 01 33.75	303 44 59	Governor's Island, 2	123 45 47	1980.3	2165.6	1.23
			16 06 44	Blind Asylum	196 06 18	3138.7	3432.4	1.95
Ship Yard, wharf post	42 21 48.14	71 01 20.53	313 16 35	Governor's Island, 2	133 17 14	1846.2	2019.0	1.15
			20 14 01	Blind Asylum	200 14 36	3390.3	3707.5	2.11
Bird Island Beacon	42 21 16.07	71 00 54.89	290 02 26	Governor's Island, 2	110 02 48	806.3	881.8	0.50
			38 46 43	Blind Asylum	218 45 51	2807.1	3069.8	1.74
Fort Independence, flagstaff	42 20 16.92	71 00 23.85	80 43 12	South Boston Point	260 42 39	1125.6	1230.9	0.70
			181 44 10	Governor's Island, 2	1 44 11	1549.3	1694.3	0.96
Hog Island Tripod	42 23 28.20	71 00 18.62	60 45 58	East Boston Reservoir	240 44 57	2363.1	2584.2	1.47
			122 46 32	Powderhorn	302 45 43	1967.2	2151.3	1.22
Chelsea, cross on dark spire	42 23 38.49	71 01 33.63	101 07 08	Tufts	281 03 33	7438.2	8134.2	4.62
			184 40 09	Powderhorn	4 40 11	749.7	819.8	[illegible]
Chelsea, white spire, (martin-hole windows.)	42 23 22.58	71 01 58.85	101 17 06	Ten-Hill Farm	281 15 08	4093.8	4476.9	2.54
			207 15 28	Powderhorn	27 15 47	1393.0	1523.4	0.86
Chelsea, white spire, with clock	42 23 25.45	71 01 57.12	100 00 33	Ten-Hill Farm	279 58 33	4116.9	4502.1	2.56
			207 26 10	Powderhorn	27 26 28	1298.7	1420.2	0.81
Chelsea, white spire (three tiers windows)	42 23 34.22	71 01 55.06	96 09 01	Ten-Hill Farm	276 07 00	4125.0	4511.0	2.56
			212 05 58	Powderhorn	32 06 14	1037.7	1134.8	0.64
Chelsea, tall dark spire	42 23 28.59	71 01 55.83	104 22 08	Tufts	284 18 48	7010.4	7666.3	4.36
			352 07 25	East Boston Reservoir	172 07 30	1177.9	1288.1	0.73
Chelsea, brown tower	42 23 27.01	71 01 25.34	25 36 49	East Boston Reservoir	205 36 33	1239.7	1355.7	0.77
			173 21 25	Powderhorn	353 21 21	1108.9	1212.6	0.69
East Boston, dark spire of brick church.	42 22 24.79	71 02 00.85	119 02 48	Tufts	298 59 31	7636.8	8351.3	4.75
			192 44 40	Powderhorn	12 45 00	3097.7	3387.5	1.92
East Boston, dark spire of granite church.	42 22 14.07	71 02 07.38	121 44 42	Tufts	301 41 30	7675.3	8393.5	4.77
			193 57 20	Powderhorn	13 57 45	3453.8	3777.0	2.15
Chimney of Gas Works, in north end of Boston.	42 21 59.92	71 03 07.35	130 56 53	Tufts	310 54 21	6826.3	7465.0	4.24
			210 11 24	Powderhorn	30 12 29	4383.3	4793.4	2.73
Charlestown, cross on brick church	42 22 19.89	71 03 27.56	220 02 42	Powderhorn	40 04 01	4144.3	4532.1	2.57
			247 07 27	East Boston Reservoir	67 08 34	2458.7	2688.8	1.53
Bunker Hill, cross on Catholic church.	42 22 51.36	71 03 39.65	123 09 30	Tufts	303 07 20	5276.7	5770.4	3.28
			233 11 42	Powderhorn	53 13 09	3675.3	4019.2	2.28
Chimney of Gas Works, near Malden bridge.	42 23 16.77	71 04 08.65	133 05 56	Ten-Hill Farm	313 05 25	1433.3	1567.4	0.89
			248 31 38	Powderhorn	68 33 24	3874.9	4237.5	2.41
Marine Hospital, cupola	42 23 19.23	71 02 22.64	104 35 55	Ten-Hill Farm	284 34 13	3586.4	3922.0	2.23
			221 22 59	Powderhorn	41 23 34	1787.9	1955.2	1.11
Edgeworth Mills, round chimney	42 24 59.41	71 04 09.84	295 41 43	Powderhorn	115 43 30	4032.0	4409.3	2.50
			24 58 58	Ten-Hill Farm	204 58 28	2413.1	2638.9	1.50
New England Glass Company, chimney.	42 22 19.37	71 04 19.26	137 47 52	Tufts	317 46 08	5227.9	5717.0	3.25
			230 21 01	Powderhorn	50 22 54	4998.3	5466.0	3.10
Church at head of Miller's river	42 22 42.08	71 05 27.77	37 08 22	Corey	217 06 52	5057.7	5530.9	3.14
			75 25 15	Mount Auburn	255 23 19	4056.4	4436.0	2.52
Somerville, red church on hill	42 23 10.00	71 05 31.44	141 08 17	Tufts	321 07 20	2966.7	3244.3	1.84
			253 30 16	Powderhorn	73 32 58	5735.1	6271.8	3.56
West chimney of Grain Mill, near turnpike.	42 24 03.20	71 05 30.64	270 08 01	Powderhorn	90 10 43	5480.9	5993.8	3.41
			298 40 36	Ten-Hill Farm	118 41 00	944.4	1032.8	0.59
Cupola of Brick Factory, near Mystic river.	42 24 30.79	71 05 06.06	279 58 04	Powderhorn	100 00 29	4994.2	5461.5	3.10
			85 43 49	Tufts	265 42 37	2448.5	2677.6	1.52
Tall chimney on north side of Mystic river.	42 24 34.20	71 05 00.92	281 25 07	Powderhorn	101 27 29	4898.3	5356.7	3.04
			353 58 09	Ten-Hill Farm	173 58 13	1417.5	1550.1	0.88

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Boston Harbor, and Hope Bay, Rhode Island.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Tall square chimney in Medford, near bridge.	42 24 50.19	71 06 10.59	282 52 39 51 02 41	Powderhorn Tufts	102 55 48 231 02 12	6559.3 1242.6	7173.1 1358.8	4.07 0.77
Malden, yellow spire	42 25 36.79	71 03 40.42	314 25 33 63 15 00	Powderhorn Tufts	134 27 00 243 12 50	4145.4 4926.9	4533.3 5387.9	2.58 3.06
Navy Yard, chimney	42 22 28.05	71 02 48.12	122 47 40 211 08 16	Tufts Powderhorn	302 45 15 31 09 08	6657.0 3412.3	7279.8 3731.6	4.13 2.12
Boston Jail, cupola	42 21 41.26	71 03 53.39	140 53 58 216 43 48	Tufts Powderhorn	320 51 57 36 45 24	6505.9 5446.2	7114.6 5955.8	4.04 3.38
State Prison, cupola	42 22 26.25	71 03 47.80	130 52 08 226 25 48	Tufts Powderhorn	310 50 03 46 27 20	5595.0 4319.1	6118.5 4723.3	3.47 2.68
East Cambridge Court-house, cupola	42 22 09.99	71 04 27.45	89 40 37 229 14 16	Mount Auburn Powderhorn	269 38 01 49 16 15	5305.9 5328.4	5802.4 5827.0	3.30 3.31
Cambridgeport, dome of observatory	42 21 17.07	71 06 14.83	54 30 39 119 20 20	Corey Mount Auburn	234 29 41 299 18 56	2427.5 3268.3	2654.6 3574.1	1.51 2.03
Cambridgeport Redoubt, flagstaff	42 21 21.90	71 05 56.19	57 02 18 113 54 54	Corey Mount Auburn	237 01 07 293 53 18	2864.0 3583.0	3132.0 3918.3	1.78 2.23
Cambridgeport, flagstaff near engine-house.	42 21 43.60	71 04 54.61	59 42 37 151 29 05	Corey Tufts	239 40 45 331 27 45	4415.3 5663.2	4828.5 6193.1	2.74 3.52
West Boston Bridge, pole on draw	42 21 39.51	71 04 05.07	66 59 41 98 53 58	Corey Mount Auburn	246 57 15 278 51 07	5373.6 5888.4	5876.4 6439.4	3.34 3.66
Carpet Cleaning Factory, ventilator	42 21 14.63	71 04 18.89	73 56 24 106 57 49	Corey Mount Auburn	253 54 08 286 55 07	4818.0 5751.7	5268.8 6289.9	2.99 3.58
Milldam, chimney of yellow house	42 20 54.23	71 05 30.65	76 44 09 163 52 14	Corey Tufts	256 42 41 343 51 19	3069.5 6765.3	3356.7 7398.3	1.91 4.20
Milldam Regatta House, flagstaff	42 21 02.90	71 04 57.98	113 52 36 75 25 17	Mount Auburn Tufts	293 50 20 255 23 27	5038.4 3859.7	5509.9 4220.8	3.13 2.40
North Brighton, dark spire	42 21 11.69	71 07 51.33	349 25 10 160 03 00	Corey Mount Auburn	169 25 17 340 02 41	1260.6 1879.7	1378.6 2055.6	0.78 1.17
Cambridge Gas Works, chimney	42 22 22.37	71 07 15.77	187 53 43 9 38 43	Tufts Corey	7 53 58 189 38 26	3815.8 3473.2	4172.8 3798.2	2.37 2.16
Planing Mill, chimney	42 22 14.11	71 06 56.21	17 59 44 85 13 36	Corey Mount Auburn	197 59 14 265 12 40	3332.5 1909.1	3644.3 2087.8	2.07 1.19
Varnish Factory, chimney	42 21 47.55	71 06 45.31	28 33 14 107 04 10	Corey Mount Auburn	208 32 36 287 03 07	2675.3 2250.8	2925.6 2461.4	1.66 1.40
Riverside Press, chimney	42 21 44.04	71 06 36.04	33 37 56 108 01 24	Corey Mount Auburn	213 37 12 288 00 14	2692.1 2485.8	2944.0 2718.4	1.67 1.55
Charles River Tripod	42 21 07.42	71 06 39.27	129 39 49 177 04 55	Mount Auburn Tufts	309 38 42 357 04 46	2974.9 6099.7	3253.3 6670.4	1.85 3.79
Chimney of small red house on marsh.	42 24 43.91	71 05 46.70	68 46 26 325 01 30	Tufts Ten-Hill Farm	248 45 41 145 02 05	1622.5 2086.1	1774.3 2281.3	1.01 1.30
Hope Bay, Rhode Island.								
QUAKER	41 34 55.14	71 14 57.37						
Mount Hope	41 40 23.95	71 14 05.17	6 47 20	Quaker	186 46 45	10213.9	11169.6	6.35
Slade	41 43 39.04	71 09 48.02	44 40 11	Mount Hope	224 37 20	8459.4	9251.0	5.26
Blackbeard	41 40 26.68	71 10 37.76	89 00 21	Mount Hope	268 58 03	4797.5	5246.4	2.98
Mattapoiset	41 42 38.29	71 12 30.70	27 47 44 327 14 25	Mount Hope Blackbeard	207 46 41 147 15 39	4685.0 4827.2	5123.4 5278.9	2.91 3.00
Toweset	41 41 57.04	71 14 12.70	356 31 42 299 15 57	Mount Hope Blackbeard	176 31 47 119 18 20	2877.5 5698.3	3146.8 6231.5	1.79 3.54
Anthony	41 38 44.17	71 12 57.59	153 04 36	Mount Hope	333 03 50	3452.3	3775.3	2.15
Bristol, Methodist church spire	41 40 13.20	71 16 10.88	263 29 08 350 09 00	Mount Hope Quaker	83 30 32 170 09 49	2668.3 9957.6	2918.0 10889.3	1.66 6.19
Fall River, 2	41 42 37.56	71 08 24.29	62 25 25 134 25 48	Mount Hope Slade	242 21 38 314 24 52	8894.5 2709.9	9726.7 2963.4	5.53 1.68
Somerset	41 44 05.43	71 09 45.42	325 19 12 41 20 07	Fall River, 2 Mount Hope	145 20 06 221 17 15	3295.8 9096.1	3604.1 9947.2	2.05 5.65
Somerset, spire	41 44 09.49	71 09 45.77	326 24 26 40 46 51	Fall River, 2 Mount Hope	146 25 20 220 43 58	3404.1 9185.2	3722.6 10044.7	2.12 5.71
Fall River, derrick	41 42 17.14	71 09 35.65	60 45 44 176 07 56	Mount Hope Somerset	240 42 45 356 07 50	7143.8 3348.0	7812.3 3661.2	4.44 2.08

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section I.—Hope Bay, Rhode Island.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Durfee, cupola	41 42 34.20	71 08 43.72	61 38 00	Mount Hope	241 34 26	8449.1	9239.7	5.25
			143 23 40	Slade	323 22 57	2492.2	2725.4	1.55
Dodge's Stable, turret	41 40 54.15	71 09 19.16	79 54 48	Mount Hope	259 52 18	5309.3	5806.1	3.30
			188 02 57	Slade	8 03 18	5137.5	5618.2	3.19
Fall River, spire	41 42 04.69	71 08 53.93	38 27 36	Blackbeard	218 26 27	3860.7	4222.0	2.40
			101 42 23	Mattapoiset	281 39 59	5117.0	5595.8	3.18
Fall River, tower	41 41 58.70	71 09 04.32	67 14 10	Mount Hope	247 10 50	7545.8	8251.8	4.69
			161 55 49	Slade	341 55 20	3256.2	3560.9	2.02
West	41 38 42.24	71 15 20.97	209 11 28	Mount Hope	29 12 18	3594.3	3930.6	2.23
			268 57 26	Anthony	88 59 01	3318.2	3628.7	2.06
Pappoose Squaw, 2	41 39 13.02	71 17 41.42	246 21 15	Mount Hope	66 23 39	5459.8	5970.7	3.39
			286 16 29	West	106 18 02	3385.5	3702.3	2.10
Hog Island, 2	41 38 38.30	71 16 29.75	122 51 49	Pappoose Squaw, 2	302 51 01	1973.9	2158.6	1.23
			225 43 48	Mount Hope	45 45 24	4669.9	5106.8	2.90
Globe Village, chimney	41 41 15.09	71 10 02.75	74 18 07	Mount Hope	254 15 26	5823.9	6368.9	3.62
			126 53 55	Mattapoiset	306 52 17	4276.6	4676.7	2.66
Spar Island	41 41 15.21	71 12 53.63	46 17 34	Mount Hope	226 16 46	2288.7	2502.8	1.42
			125 13 45	Toweset	305 12 52	2237.8	2447.2	1.39

Section II.—Connecticut River.

Williams	41 21 16.61	72 30 49.11						
Nickerson	41 23 51.55	72 19 19.01	73 27 59	Williams	252 20 23	16731.5	18297.0	10.40
Malicah	41 20 32.83	72 19 48.68	186 24 51	Nickerson	6 25 11	6168.3	6745.5	3.83
			95 05 19	Williams	274 58 03	15410.9	16852.9	9.58
Brown's Hill	41 09 08.91	72 17 15.87						
Beacon Hill	41 17 32.27	72 23 48.34	208 07 47	Nickerson	28 10 41	13269.2	14510.8	8.24
			329 28 46	Brown's Hill	149 33 05	18017.4	19703.3	11.19
Lay's Hill, 2	41 16 55.85	72 17 44.49	97 32 01	Beacon Hill	277 27 59	8609.1	9414.7	5.35
			357 37 29	Brown's Hill	177 37 46	14415.8	15764.6	8.96
Ferry Hill, 2	41 18 55.56	72 21 36.47	304 01 10	Lay's Hill, 2	124 03 45	6596.8	7214.0	4.10
			50 04 00	Beacon Hill	230 02 33	4007.6	4382.6	2.49
Essex, 2	41 20 31.00	72 23 28.58	223 07 33	Nickerson	43 10 16	8479.3	9272.7	5.27
			318 27 50	Ferry Hill, 2	138 29 04	3932.0	4299.9	2.44
Lord	41 21 28.56	72 20 26.88	67 12 49	Essex, 2	247 10 49	4581.3	5009.9	2.85
			332 40 22	Malicah	152 40 47	1934.5	2115.5	1.20
Book Hill	41 22 04.21	72 24 26.87	245 07 52	Nickerson	65 11 16	7881.6	8619.1	4.90
			334 45 44	Essex, 2	154 46 23	3178.5	3475.9	1.97
Honey Hill	41 23 47.52	72 21 13.85	267 19 40	Nickerson	87 20 56	2670.3	2920.1	1.66
			341 45 01	Malicah	161 45 57	6323.0	6914.7	3.93
Doane	41 22 24.86	72 24 27.08	298 04 39	Malicah	118 07 43	7335.1	8021.5	4.56
			240 23 07	Honey Hill	60 25 15	5162.6	5645.6	3.21
Cedar	41 22 39.65	72 23 19.54	3 01 48	Essex, 2	183 01 42	3974.2	4346.1	2.47
			308 34 46	Malicah	128 37 05	6270.2	6856.9	3.90
Ely, 2	41 21 49.16	72 22 06.67	38 17 57	Essex, 2	218 17 03	3072.0	3359.5	1.91
			132 37 04	Cedar	312 36 16	2300.6	2515.9	1.43
Ely, 3	41 21 50.65	72 22 04.21	38 35 55	Essex, 2	218 34 59	3143.5	3437.6	1.96
			353 10 53	Ferry Hill, 2	173 11 12	5439.2	5948.2	3.38
Selden	41 24 17.93	72 23 42.25	350 07 27	Cedar	170 07 42	3077.2	3365.2	1.91
			16 37 34	Doane	196 37 05	3640.0	3980.6	2.26
Cone	41 24 36.46	72 26 32.31	281 30 23	Honey Hill	101 33 53	7548.8	8255.1	4.69
			278 13 00	Selden	98 14 52	3990.4	4363.7	2.48
Wahginnicut	41 23 41.29	72 25 25.43	330 05 44	Doane	150 06 23	2719.4	2973.9	1.69
			137 36 56	Cone	317 36 12	2304.0	2519.6	1.43
Brooks	41 25 21.95	72 25 22.50	49 07 17	Cone	229 06 31	2144.1	2344.7	1.33
			1 15 17	Wahginnicut	181 15 15	3105.9	3396.5	1.93
Noyes	41 18 57.28	72 20 12.63	122 24 49	Essex, 2	302 22 40	5395.9	5900.7	3.35
			88 27 08	Ferry Hill, 2	268 26 13	1950.6	2133.2	1.21

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Connecticut River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Gelston	41 26 55.29	72 26 11.00	338 38 28	Brooks	158 39 00	3091.6	3380.9	1.92
			6 35 32	Cone	186 35 18	4311.3	4714.7	2.68
Holt	41 25 39.02	72 27 09.41	292 34 54	Honey Hill	112 38 49	8944.4	9781.3	5.56
			281 58 04	Brooks	101 59 15	2537.4	2774.8	1.58
Gravel Bluff	41 19 18.11	72 20 45.28	310 13 53	Noyes	130 14 15	994.7	1087.7	0.62
			59 42 39	Ferry Hill, 2	239 42 06	1378.7	1507.7	0.86
Bald Hill	41 27 40.82	72 24 46.35	325 32 55	Honey Hill	145 35 16	8725.3	9541.7	5.42
			23 23 54	Cone	203 22 44	6196.2	6776.0	3.85
Mount Parnassus	41 28 01.34	72 24 20.03	317 46 03	Nickerson	137 49 22	10402.4	11375.7	6.46
			0 49 33	Book Hill	180 49 29	11017.7	12048.5	6.85
Higgins' Wharf	41 19 28.67	72 20 12.86	62 17 26	Ferry Hill, 2	242 16 31	2196.2	2401.7	1.36
			149 25 19	Ely, 3	329 24 05	5087.4	5563.4	3.16
Pilgrim	41 19 47.27	72 20 06.91	52 33 44	Ferry Hill, 2	232 32 45	2623.1	2868.6	1.63
			106 01 11	Essex, 2	286 01 58	4878.8	5335.3	3.03
Ayer	41 19 53.59	72 21 17.85	318 51 55	Noyes	138 52 38	2305.9	2521.6	1.43
			239 42 16	Malicah	59 43 15	2400.5	2625.1	1.49
Pine Island	41 20 23.82	72 20 30.41	29 26 20	Ferry Hill, 2	209 25 36	3125.9	3418.3	1.94
			93 04 23	Essex, 2	273 02 25	4147.9	4536.0	2.58
Hayden's Point	41 20 34.89	72 22 17.99	186 32 56	Ely, 2	6 33 03	2306.1	2521.9	1.43
			187 48 02	Ely, 3	7 48 11	2358.8	2579.5	1.46
Beckwith's Point	41 21 10.19	72 21 02.51	10 45 48	Ferry Hill, 2	190 45 26	4227.3	4622.9	2.63
			70 24 54	Essex, 2	250 23 17	3604.5	3941.7	2.24
Essex, Congregationalist church	41 21 07.64	72 23 13.72	282 40 15	Malicah	102 42 30	4885.5	5342.6	3.04
			227 08 42	Nickerson	47 11 17	7436.5	8132.3	4.62
Essex, Baptist church	41 21 15.93	72 23 13.05	285 36 39	Malicah	105 38 54	4932.8	5394.4	3.07
			228 32 40	Nickerson	48 35 15	7253.2	7931.9	4.51
Essex, Episcopal church spire	41 21 08.76	72 23 11.91	230 34 44	Ely, 2	50 35 27	1962.9	2146.6	1.22
			283 10 48	Malicah	103 13 02	4852.4	5306.4	3.02
Williams's Dock	41 21 35.55	72 23 08.09	213 05 36	Honey Hill	33 06 52	4859.5	5314.2	3.02
			273 17 00	Lord	93 18 46	3752.7	4103.9	2.33
Hamburg Cove	41 22 34.34	72 22 00.49	313 00 11	Lord	133 01 13	2974.9	3253.3	1.85
			95 06 08	Cedar	275 05 16	1843.9	2016.5	1.15
Joshua Rock	41 22 49.52	72 22 17.29	21 11 57	Essex, 2	201 11 10	4582.6	5011.3	2.85
			78 07 41	Cedar	258 07 00	1477.7	1616.0	0.92
Buckingham	41 22 54.03	72 23 27.40	241 58 54	Honey Hill	62 00 22	3513.7	3842.4	2.18
			172 24 23	Selden	352 24 13	2611.0	2855.3	1.62
Selden's Neck	41 23 40.73	72 24 34.22	355 56 39	Doane	175 56 44	2346.4	2565.9	1.46
			90 49 28	Wahginnicut	270 48 54	1189.6	1300.9	0.74
Brockway	41 23 21.32	72 22 58.23	251 33 15	Honey Hill	71 34 24	2555.6	2794.7	1.59
			7 38 52	Essex, 2	187 38 32	5301.2	5797.2	3.30
Joe Post's Light-house	41 23 18.05	72 24 44.79	127 12 39	Wahginnicut	307 12 12	1185.2	1296.1	0.74
			167 05 52	Brooks	347 05 27	3920.8	4287.7	2.44
Grassy Hill	41 23 43.27	72 16 55.92	57 00 38	Essex, 2	236 56 19	10882.5	11900.7	6.76
			94 24 16	Nickerson	274 22 41	3333.5	3645.4	2.07
Locust	41 24 59.92	72 26 57.25	166 49 47	Holt	346 49 39	1238.6	1354.5	0.77
			252 49 41	Brooks	72 50 44	2302.6	2518.0	1.43
East Haddam, Episcopal church spire.	41 27 35.42	72 27 13.25	310 04 57	Honey Hill	130 08 55	10910.7	11931.6	6.78
			358 34 33	Holt	178 34 36	3591.9	3928.0	2.23
East Haddam, Congregationalist church spire.	41 28 47.02	72 26 28.49	310 44 41	Bald Hill	130 45 49	3128.1	3420.8	1.94
			295 17 23	Mount Parnassus	115 18 48	3296.6	3605.0	2.05
Deep River, spire	41 23 09.81	72 25 44.29	157 21 03	Cone	337 20 31	2895.9	3166.8	1.80
			307 41 52	Doane	127 42 43	2267.3	2479.5	1.41
Chester, church steeple	41 24 02.32	72 26 54.69	263 49 57	Selden	83 52 04	4495.2	4915.8	2.79
			273 16 12	Honey Hill	93 19 57	7929.8	8671.8	4.93
Quarry	41 24 24.42	72 24 56.62	26 42 18	Wahginnicut	206 41 59	1489.3	1628.7	0.92
			161 17 30	Brooks	341 17 13	1873.7	2049.0	1.17
Hadlyme, cupola	41 25 51.29	72 24 00.86	351 28 08	Selden	171 28 20	2912.0	3184.5	1.81
			64 29 03	Brooks	244 28 09	2100.4	2296.9	1.31
Wahginnicut House, flag	41 23 40.70	72 25 18.68	178 22 19	Brooks	358 22 16	3124.5	3416.8	1.94
			242 50 37	Selden	62 51 41	2516.8	2752.3	1.56
Horton's Point Light-house	41 05 04.20	72 26 25.05	188 58 41	Beacon Hill	9 00 24	23362.1	25548.1	14.52
			239 26 32	Brown's Hill	59 32 33	14868.7	16260.0	9.24

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Yonkers to Tarrytown, and Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Kieckout	41 05 16.18	73 50 22.14						
Piermont, engine-house	41 02 27.18	73 54 31.93	227 50 55	Kieckout	47 53 39	7862.7	8598.5	4.89
Piermont, pier	41 02 31.69	73 53 29.06	220 20 11	Kieckout	40 22 14	6738.9	7369.4	4.19
Smith, 2	41 04 40.95	73 54 43.72	259 19 25	Kieckout	79 22 17	6212.0	6793.3	3.86
			356 10 56	Engine-house	176 11 04	4135.4	4522.3	2.57
Van Tassel	41 03 18.25	73 51 53.32	122 40 50	Smith, 2	302 38 58	4725.6	5167.8	2.94
			66 57 59	Engine-house	246 56 15	4024.9	4401.6	2.50
Irvington, pier	41 02 23.43	76 52 08.30	191 41 36	Van Tassel	11 41 46	1726.7	1888.2	1.07
			91 58 34	Engine-house	271 57 00	3356.0	3670.1	2.09
Upper Dobbs's Ferry	41 01 06.09	73 52 26.56	190 08 04	Irvington, pier	10 08 16	2422.9	2649.6	1.51
			130 30 10	Engine-house	310 28 48	3850.1	4210.3	2.39
Meadow Point	41 01 03.97	73 53 49.39	158 50 04	Engine-house	338 49 36	2751.2	3008.6	1.71
			223 55 32	Irvington, pier	43 56 38	3403.1	3721.5	2.12
Duer	40 59 50.82	73 53 50.46	180 38 29	Meadow Point	0 38 30	2255.7	2466.7	1.40
			220 10 49	Upper Dobbs's Ferry	40 11 44	3038.3	3322.6	1.89
Hastings	40 59 29.85	73 52 50.25	114 41 19	Duer	294 40 39	1548.5	1693.4	0.96
			154 32 59	Meadow Point	334 32 20	3214.3	3515.1	2.00
N. Boat-house	41 00 09.69	73 52 42.78	69 48 02	Duer	249 47 18	1685.5	1843.2	1.05
			8 05 41	Hastings	188 05 36	1241.1	1357.2	0.77
Rockwell	40 59 34.22	73 53 51.17	235 36 07	N. Boat-house	55 36 52	1936.9	2118.1	1.20
			275 23 53	Hastings	95 24 33	1430.1	1563.9	0.89
Baumer's Pier	40 58 12.82	73 53 06.47	157 24 27	Rockwell	337 23 58	2719.0	2973.4	1.69
			189 04 05	Hastings	9 04 16	2405.7	2630.8	1.50
North Quarry	40 58 01.94	73 54 17.30	258 32 08	Baumer's Pier	78 32 54	1689.7	1847.8	1.05
			216 52 54	Hastings	36 53 31	3389.9	3707.1	2.10
Mechan	40 57 15.70	73 53 32.22	143 31 36	North Quarry	323 31 06	1773.2	1939.1	1.10
			198 51 52	Baumer's Pier	18 52 09	1861.4	2035.5	1.16
South Quarry	40 57 56.04	73 54 19.06	318 37 45	Mechan	138 38 16	1657.4	1812.5	1.03
			253 01 59	Baumer's Pier	73 02 47	1774.3	1940.3	1.10
Upper Closter	40 56 47.34	73 54 46.94	197 06 28	South Quarry	17 06 46	2216.3	2423.7	1.38
			243 24 51	Mechan	63 25 41	1954.1	2137.0	1.21
Glenwood	40 56 50.28	73 53 42.85	157 20 21	South Quarry	337 19 57	2196.9	2402.4	1.36
			197 37 38	Mechan	17 37 45	822.0	898.9	0.51
Van Dusen's Observatory	41 02 38.12	73 51 14.35	35 16 11	Duer	215 14 29	6318.4	6909.6	3.92
			51 17 18	Meadow Point	231 15 36	4641.9	5076.3	2.88
High Cupola, S	40 58 18.94	73 52 46.60	146 58 35	Rockwell	326 57 53	2768.9	3027.9	1.72
			76 06 57	North Quarry	256 05 57	2184.4	2388.8	1.36
Lilienthal, flagstaff	40 57 23.10	73 53 07.64	121 19 02	South Quarry	301 18 15	1954.7	2137.6	1.22
			64 37 00	Upper Closter	244 35 55	2570.8	2811.4	1.60
Upper Dobbs's Ferry, Methodist church.	41 00 53.74	73 52 04.69	97 21 24	Meadow Point	277 20 15	2466.1	2696.9	1.53
			51 52 33	Duer	231 51 24	3142.1	3436.1	1.95
Hudson River—Hudson to Troy.								
Catskill	42 11 21.78	74 01 55.16						
Mount Merino	42 14 03.05	73 48 43.98	74 44 26	Catskill	254 35 54	18815.4	20575.9	11.69
Powell	42 23 18.65	73 51 31.23	347 23 26	Mount Merino	167 25 18	17564.4	19207.9	10.92
			32 55 47	Catskill	212 48 47	26333.4	28797.4	16.36
Merwin	42 21 21.68	73 41 03.42	104 09 49	Powell	284 02 46	14808.6	16194.3	9.20
			37 58 47	Mount Merino	217 53 37	17158.7	18764.2	10.66
Yellow Pine	42 29 26.88	73 40 08.34	4 48 44	Merwin	184 48 07	15022.5	16428.1	9.34
			54 00 33	Powell	233 52 52	19302.7	21108.9	11.99
Stanton	42 27 00.48	73 52 06.45	254 32 11	Yellow Pine	74 40 16	17012.9	18604.8	10.57
			304 31 23	Merwin	124 38 50	18414.9	20138.0	11.44
Traver	42 30 12.85	73 45 20.06	281 14 22	Yellow Pine	101 17 53	7256.9	7935.9	4.51
			57 26 29	Stanton	237 21 55	11016.7	12047.4	6.85
Blodgett	42 30 45.19	73 53 16.75	275 11 40	Traver	95 17 02	10927.2	11949.7	6.79
			346 57 17	Stanton	166 58 05	7116.1	7782.0	4.42
Academy Hill	42 14 35.94	73 46 16.43	73 18 55	Mount Merino	253 17 16	3531.8	3862.3	2.20
			209 46 12	Merwin	29 49 43	14425.6	15775.4	8.96

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Hallenbeck, South	42 16 17.21	73 49 39.19	303 53 45	Academy Hill	123 56 01	5599.6	6123.5	3.48
			342 59 58	Mount Merino	163 00 35	4328.4	4733.4	2.69
Van Hoesen	42 18 18.79	73 53 34.54	319 48 55	Mount Merino	139 52 10	10323.0	11288.9	7.42
			304 22 05	Academy Hill	124 27 00	12167.8	13306.3	7.56
Hotchkiss	42 17 32.45	73 45 45.46	66 35 06	Hallenbeck, South	246 32 29	5836.2	6382.3	3.63
			7 25 33	Academy Hill	187 25 12	5491.8	6005.7	3.41
Tryon	42 18 42.03	73 47 28.77	347 40 46	Academy Hill	167 41 34	7770.8	8497.9	4.83
			312 12 36	Hotchkiss	132 13 46	3194.8	3493.7	1.98
Parade	42 15 20.71	73 47 31.23	308 50 43	Academy Hill	128 51 33	2201.8	2407.9	1.37
			120 44 35	Hallenbeck, South	300 43 09	3411.4	3730.6	2.12
Merino Point	42 14 49.48	73 48 33.68	150 59 22	Hallenbeck, South	330 58 38	3095.4	3385.0	1.92
			236 02 42	Parade	56 03 24	1725.4	1886.8	1.07
Wiswell	42 14 24.06	73 49 15.44	67 39 41	Goodes	247 38 46	2017.8	2206.6	1.25
			49 03 47	Rodger's Island, North	229 03 03	2002.9	2190.3	1.24
Nichols	42 15 26.72	73 48 47.24	344 51 34	Merino Point	164 51 43	1190.4	1301.7	0.74
			358 20 50	Mount Merino	178 20 52	2582.5	2824.1	1.60
Dober's Island	42 15 47.67	73 47 59.05	313 14 45	Academy Hill	133 15 54	3229.6	3531.8	2.01
			23 51 10	Merino Point	203 50 47	1963.0	2146.7	1.22
Railroad, 95	42 16 50.55	73 46 28.99	27 14 05	Parade	207 13 23	3117.3	3409.0	1.94
			158 17 55	Tryon	338 17 15	3701.9	4048.3	2.30
Grove Point	42 16 42.66	73 47 23.94	259 03 25	Railroad, 95	79 04 02	1282.2	1402.2	0.80
			25 22 10	Dober's Island	205 21 46	1877.7	2053.4	1.17
Hallenbeck, North	42 18 36.55	73 49 25.31	329 44 30	Academy Hill	149 46 37	8592.6	9396.6	5.34
			266 22 15	Tryon	86 23 34	2674.1	2924.3	1.66
Railroad, 94	42 15 29.49	73 47 24.15	52 14 21	Merino Point	232 13 34	2015.8	2204.4	1.25
			125 02 30	Dober's Island	305 02 07	976.7	1068.1	0.61
Athens Wharf	42 15 22.96	73 48 19.47	12 50 41	Mount Merino	192 50 24	2529.1	2765.8	1.57
			17 29 26	Merino Point	197 29 16	1083.3	1184.7	0.67
Brandeau	42 14 48.27	73 49 54.03	310 59 24	Mount Merino	131 00 11	2127.1	2326.2	1.32
			243 42 50	Athens Wharf	63 43 54	2417.4	2643.6	1.50
Porter	42 16 28.41	73 47 57.68	343 49 13	Parade	163 49 31	2174.9	2378.4	1.35
			337 05 18	Railroad, 94	157 05 41	1973.7	2158.3	1.23
Athens, Dutch Reformed church	42 15 46.09	73 48 22.74	303 32 58	Parade	123 33 33	1416.6	1549.1	0.88
			290 52 06	Railroad, 94	110 52 45	1437.0	1571.4	0.89
Athens, Episcopal church	42 15 52.00	73 48 08.28	318 40 04	Parade	138 40 29	1285.6	1405.9	0.80
			304 28 34	Railroad, 94	124 29 04	1226.7	1341.5	0.76
Hudson, Episcopal church	42 14 58.22	73 47 02.96	302 48 12	Academy Hill	122 48 43	1269.1	1387.9	0.79
			139 53 05	Dober's Island	319 52 27	1994.8	2181.4	1.24
Hudson, Roman Catholic church	42 15 03.10	73 47 19.30	146 29 01	Dober's Island	326 28 34	1649.3	1803.7	1.02
			125 30 38	Hallenbeck, South	305 29 04	3937.7	4306.1	2.45
Dubois	42 16 06.51	73 46 51.90	146 39 08	Grove Point	326 38 46	1644.8	1798.7	1.02
			201 07 36	Railroad, 95	21 07 51	1456.6	1592.9	0.91
Quarry Point	42 17 33.18	73 47 07.66	326 02 01	Railroad, 95	146 02 27	1585.6	1733.9	0.99
			270 40 35	Hotchkiss	90 41 30	1883.2	2059.4	1.17
Coventry	42 17 52.62	73 45 59.71	19 18 17	Railroad, 95	199 17 57	2029.1	2219.0	1.26
			41 48 00	Grove Point	221 47 03	2894.9	3165.8	1.80
Coonly	42 17 25.90	73 47 15.08	315 55 44	Railroad, 95	135 56 15	1518.0	1660.0	0.94
			244 28 08	Coventry	64 28 59	1913.0	2092.0	1.19
Adams	42 18 13.40	73 46 38.80	315 56 55	Hotchkiss	135 57 31	1757.6	1922.1	1.09
			305 36 03	Coventry	125 36 29	1100.9	1203.9	0.69
Budd's Hill	42 22 59.00	73 47 39.33	288 18 10	Merwin	108 22 37	9542.3	10435.1	5.93
			96 32 44	Powell	276 30 08	5338.4	5837.9	3.32
Coxsackie Hill	42 20 55.33	73 47 28.30	264 41 21	Merwin	84 45 40	8845.2	9672.9	5.50
			128 31 51	Powell	308 29 07	7102.3	7766.9	4.42
Stockport	42 18 41.24	73 46 03.55	356 39 16	Coventry	176 39 18	1502.6	1643.1	0.94
			348 56 42	Hotchkiss	168 56 54	2162.5	2364.8	1.34
Alvord	42 19 17.52	73 45 53.79	240 00 51	Merwin	60 04 06	7671.3	8389.1	4.77
			63 16 45	Tryon	243 15 41	2434.8	2662.6	1.51
Lamphear	42 18 58.54	73 46 48.56	350 53 14	Adams	170 53 21	1410.4	1542.3	0.88
			297 21 51	Stockport	117 22 21	1160.5	1269.0	0.72
Reed	42 19 52.43	73 46 51.21	333 34 22	Stockport	153 34 54	2452.4	2681.9	1.52
			357 54 24	Lamphear	177 54 26	1663.7	1819.3	1.04

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Reed, cupola	42 19 40.90	73 46 54.33	309 38 34	Railroad, 96	129 39 03	1271.9	1390.9	0.79
			352 29 51	Adams	172 30 01	2723.0	2977.8	1.69
Alger	42 19 44.96	73 45 44.56	132 27 10	Coxsackie Hill	312 26 00	3217.5	3518.6	2.00
			98 34 31	Reed	278 33 46	1543.5	1687.9	0.96
Railroad, 96	42 19 14.59	73 46 11.56	349 15 18	Hotchkiss	169 15 36	3207.1	3507.2	1.99
			142 07 27	Reed	322 07 00	1478.8	1617.2	0.92
Bronk	42 20 29.31	73 47 24.40	132 47 54	Powell	312 45 08	7693.3	8413.2	4.78
			259 27 56	Merwin	79 32 13	8867.4	9697.1	5.51
Stockport Hill	42 18 21.76	73 45 41.82	78 49 12	Adams	258 48 34	1330.5	1454.9	0.83
			104 19 59	Tryon	284 18 47	2527.4	2763.9	1.57
Rider	42 21 51.82	73 46 34.62	111 34 25	Powell	291 31 05	7294.7	7977.2	4.53
			35 11 03	Coxsackie Hill	215 10 27	2132.3	2331.8	1.32
Warner	42 22 59.03	73 46 38.12	357 46 59	Rider	177 47 01	2074.9	2269.1	1.29
			89 57 53	Budd's Hill	269 57 12	1400.3	1531.3	0.87
Four-mile Point Light	42 18 19.96	73 46 41.92	233 13 35	Stockport	53 14 01	1097.1	1199.8	0.68
			311 05 53	Coventry	131 06 21	1282.9	1403.0	0.80
Eugenie	42 19 46.57	73 46 07.05	5 58 31	Railroad, 96	185 58 28	991.9	1084.7	0.62
			100 08 17	Reed	280 07 47	1027.2	1123.3	0.64
Fordham	42 20 38.38	73 46 34.07	338 51 47	Eugenie	158 52 05	1714.4	1874.8	1.07
			179 41 34	Rider	359 41 34	2266.1	2478.2	1.41
Practice	42 18 58.40	73 46 51.28	180 03 20	Reed	0 03 20	1665.9	1821.7	1.04
			245 50 48	Alvord	65 51 27	1442.6	1577.5	0.90
Worden	42 21 34.23	73 47 39.13	208 04 29	Warner	28 05 10	2965.1	3242.6	1.84
			348 19 53	Coxsackie Hill	168 20 00	1225.5	1340.2	0.76
Newton Hook	42 21 11.69	73 47 02.13	328 00 04	Fordham	148 00 23	1211.9	1325.3	0.75
			129 24 55	Worden	309 24 30	1095.5	1198.0	0.68
Canalboat	42 20 15.48	73 46 59.33	306 42 01	Eugenie	126 42 36	1492.6	1632.2	0.93
			219 17 34	Fordham	39 17 51	913.4	998.8	0.57
Baker's Pier	42 20 49.63	73 47 11.00	196 35 49	Newton Hook	16 35 55	710.2	776.6	0.44
			203 27 21	Rider	23 27 46	2091.8	2287.6	1.30
Upper Landing	42 21 53.04	73 47 33.33	345 21 45	Baker's Pier	165 22 00	2022.2	2211.4	1.26
			356 18 01	Coxsackie Hill	176 18 04	1784.2	1951.2	1.11
Hogpen	42 21 58.97	73 46 49.48	79 40 28	Upper Landing	259 39 59	1019.8	1115.2	0.63
			148 22 43	Budd's Hill	328 22 10	2175.0	2378.5	1.35
Budd	42 23 07.39	73 47 24.04	283 48 17	Warner	103 48 48	1081.8	1183.1	0.67
			334 07 20	Rider	154 07 53	2591.0	2833.4	1.61
Rocky Point	42 22 22.70	73 47 37.30	230 22 34	Warner	50 23 14	1757.5	1922.0	1.09
			192 24 09	Budd	12 24 18	1411.9	1544.0	0.88
Poplar Point	42 22 45.60	73 46 51.75	55 52 11	Rocky Point	235 51 40	1258.9	1376.7	0.78
			357 55 36	Hogpen	177 55 38	1439.6	1574.3	0.89
Slang Hook	42 20 29.33	73 43 08.71	40 31 18	Reed	220 30 49	1497.7	1637.8	0.93
			69 45 55	Canal Boat	249 45 21	1234.8	1350.3	0.77
Gillett	42 25 21.17	73 44 12.20	105 49 54	Stanton	285 44 34	11262.8	12316.6	7.00
			37 16 56	Warner	217 15 18	5510.5	6026.1	3.42
Middle Bronk	42 24 25.70	73 47 15.35	247 45 19	Gillett	67 47 23	4523.5	4946.7	2.81
			342 20 13	Warner	162 20 38	2806.2	3068.8	1.74
Bronk, North	42 25 39.56	73 47 04.58	6 10 01	Middle Bronk	186 09 54	2292.3	2506.8	1.42
			353 02 08	Warner	173 02 26	4989.7	5456.6	3.10
Bailey	42 23 47.78	73 46 29.19	46 49 58	Budd's Hill	226 49 11	2199.8	2405.6	1.37
			137 56 23	Middle Bronk	317 55 52	1575.6	1723.0	0.98
Coxsackie Light	42 22 44.59	73 47 23.36	325 35 00	Rider	145 35 33	1973.1	2157.7	1.23
			212 25 43	Bailey	32 26 20	2309.8	2525.9	1.43
Coxsackie, Episcopal church	42 21 09.15	73 47 53.67	331 24 50	Bronk	151 25 10	1399.9	1530.9	0.87
			233 56 49	Rider	53 57 42	2237.3	2446.7	1.39
Coxsackie, Roman Catholic church	42 20 56.00	73 47 26.06	214 20 56	Rider	34 21 31	2086.1	2281.3	1.29
			228 31 10	Newton Hook	48 31 26	730.6	799.0	0.45
Cove Point	42 24 05.26	73 47 18.13	2 44 47	Coxsackie Light	182 44 43	2491.7	2724.9	1.55
			295 43 23	Bailey	115 43 56	1242.4	1358.6	0.77
Old Steamboat Wharf	42 23 54.92	73 46 35.98	168 33 11	Bronk, North	348 32 52	3294.1	3602.3	2.05
			136 31 36	Middle Bronk	316 31 10	1308.4	1430.8	0.81
River Bluff	42 25 32.66	73 45 59.46	15 28 48	Old Steamboat Wharf	195 28 23	3129.2	3422.0	1.94
			98 08 56	Bronk, North	278 08 12	1503.6	1644.2	0.94

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Covert	42 26 19.53	73 45 38.94	23 59 46	Budd's Hill	203 58 25	6771.7	7405.4	4.21
			13 47 27	Bailey	193 46 53	4820.7	5271.8	3.00
Railroad Bridge	42 24 43.82	73 46 13.38	145 46 13	Bronk, North	325 45 38	2080.3	2274.9	1.29
			18 54 28	Old Steamboat Wharf	198 54 13	1594.8	1744.0	0.99
Shufelt	42 28 29.03	73 40 17.08	80 29 50	Stanton	260 21 51	16433.6	17971.2	10.21
			58 12 10	Powell	238 04 35	18140.9	19838.3	11.27
Nodine	42 27 29.99	73 47 20.98	208 46 52	Traver	28 48 13	5733.3	6269.8	3.56
			82 04 49	Stanton	262 0. 36	6585.4	7201.6	4.09
Ten Eyck, 2	42 28 44.58	73 45 29.50	184 31 13	Traver	4 31 19	2731.8	2987.4	1.70
			47 54 24	Nodine	227 53 09	3432.1	3753.2	2.13
Van Ness	42 27 36.12	73 44 52.31	83 42 53	Stanton	263 38 00	9979.4	10913.2	6.20
			242 11 20	Yellow Pine	62 14 32	7330.8	8016.8	4.56
Coeyman	42 28 09.88	78 47 21.35	359 36 24	Nodine	179 36 24	1230.6	1345.8	0.77
			216 07 12	Traver	36 08 34	4697.5	5137.0	2.92
Lasher	42 31 24.29	73 46 45.54	318 28 47	Traver	138 29 45	2943.8	3219.3	1.83
			6 23 23	Nodine	186 22 59	7273.8	7954.5	4.52
Eaton	42 25 06.80	73 45 46.06	153 51 31	Nodine	333 50 27	4921.6	5382.2	3.06
			119 23 34	Bronk, North	299 22 41	2060.0	2252.7	1.28
Mull	42 30 01.56	73 46 48.40	9 02 38	Nodine	189 02 16	4735.2	5178.3	2.94
			260 11 57	Traver	80 12 57	2046.4	2237.9	1.27
Hallenbeck	42 35 54.40	73 39 48.85	2 07 54	Yellow Pine	182 07 41	11964.3	13083.7	7.44
			62 42 20	Blodgett	242 33 14	20751.1	22692.6	12.89
Thorp	42 33 18.44	73 43 46.31	325 07 51	Yellow Pine	145 10 18	8705.6	9520.2	5.41
			70 05 19	Blodgett	249 58 54	13848.4	15144.2	8.60
Ferris	42 40 34.95	73 44 53.58	321 14 35	Hallenbeck	141 18 01	11095.8	12133.9	6.89
			32 16 22	Blodgett	212 10 41	21509.6	23522.2	13.36
Ryesdorph	42 37 34.89	73 42 51.42	306 40 39	Hallenbeck	126 42 43	5188.7	5674.2	3.22
			48 30 18	Blodgett	228 23 15	19056.5	20839.6	11.84
Industrial School	42 39 09.04	73 46 16.64	304 10 05	Hallenbeck	124 14 28	10683.3	11682.9	6.64
			301 50 11	Ryesdorph	121 52 30	5504.1	6019.1	3.42
Bloomingdale	42 40 28.94	73 39 27.07	40 56 01	Ryesdorph	220 53 43	7106.3	7771.3	4.42
			3 21 21	Hallenbeck	183 21 06	8485.2	9279.2	5.27
Coast Survey Station	42 39 50.08	73 44 41.22	317 29 00	Hallenbeck	137 32 18	9861.3	10784.0	6.13
			329 02 35	Ryesdorph	149 03 49	4863.6	5318.6	3.02
Roraback	42 29 31.29	73 44 41.60	180 01 33	Coast Survey Station	0 01 33	19091.7	20878.1	11.86
			209 26 25	Hallenbeck	29 29 43	13576.2	14846.5	8.44
Albany, cathedral	42 38 49.54	73 45 16.13	36 17 54	Blodgett	216 12 29	18531.3	20265.2	11.51
			188 58 05	Ferris	8 58 20	3292.5	3600.5	2.05
Meridian	42 34 13.80	73 44 41.19	61 21 38	Blodgett	241 15 49	13408.3	14662.9	8.33
			179 59 45	Coast Survey Station	359 59 45	10375.6	11346.4	6.45
Troy University	42 43 44.43	73 40 40.90	344 25 41	Bloomingdale	164 26 31	6261.7	6847.6	3.89
			44 32 50	Ferris	224 29 59	8200.5	8967.8	5.10
Van Aernam	42 42 13.45	73 44 08.54	239 15 32	Troy University	59 17 53	5495.3	6009.5	3.41
			296 41 30	Bloomingdale	116 44 41	7172.4	7843.5	4.46
Lansing	42 44 11.12	73 42 39.17	287 00 12	Troy University	107 01 32	2813.4	3076.6	1.75
			327 27 25	Bloomingdale	147 29 35	8130.5	8891.2	5.05
Lansingburgh Spire	42 46 27.38	73 40 14.63	6 46 36	Troy University	186 46 18	5062.8	5536.6	3.15
			38 01 40	Lansing	218 00 02	5336.3	5835.6	3.32
Sherman	42 26 26.45	73 46 57.40	298 03 56	Gillett	118 05 47	4279.2	4679.6	2.66
			164 38 13	Nodine	344 37 57	2033.1	2223.3	1.26
Reed	42 27 10.92	73 45 47.04	49 32 13	Sherman	229 31 26	2113.7	2311.4	1.31
			105 20 54	Nodine	285 19 51	2225.5	2433.7	1.38
Ten Eyck, 1	42 28 48.10	73 45 33.63	5 50 04	Reed	185 49 55	3014.0	3296.0	1.87
			45 30 32	Nodine	225 29 20	3437.9	3759.5	2.14
Stuyvesant Light	42 24 40.03	73 46 23.15	198 12 52	Covert	18 13 22	3231.0	3533.3	2.01
			69 40 23	Middle Bronk	249 39 48	1272.5	1391.5	0.79
Railroad	42 26 11.90	73 46 01.45	109 21 13	Sherman	289 20 35	1355.2	1482.0	0.84
			357 52 06	River Bluff	177 52 07	1211.3	1324.6	0.75
Wood Wharf	42 25 29.82	73 46 46.89	340 33 00	Stuyvesant Light	160 33 16	1629.4	1781.9	1.01
			297 03 21	Eaton	117 04 02	1561.2	1707.3	0.97
Sutherland	42 24 46.93	73 47 00.57	193 17 52	Wood Wharf	13 18 01	1359.8	1487.0	0.84
			283 58 58	Stuyvesant Light	103 59 23	881.6	964.1	0.55

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Muitze's Kill Church	42 28 33.74	73 43 32.53	76 16 41	Stanton	256 10 54	12087.5	13218.5	7.51
			106 58 00	Blodgett	286 51 25	13941.8	15246.4	8.66
Barren Island, north	42 28 03.76	73 46 52.40	32 04 47	Nodine	212 04 28	1229.4	1344.5	0.76
			317 30 40	Reed	137 31 24	2210.8	2417.7	1.37
Burns' Wharf	42 27 11.93	73 46 03.14	107 24 32	Nodine	287 23 40	1863.5	2037.8	1.16
			144 52 16	Barren Island, north	324 51 43	1955.3	2138.3	1.22
Railroad, 29	42 27 26.92	73 46 02.97	135 11 44	Barren Island, north	315 11 11	1602.1	1752.0	1.00
			0 28 24	Burns' Wharf	180 28 24	462.4	505.6	0.29
Barren Island, south	42 28 20.03	73 47 13.51	329 50 13	Covert	149 51 17	4300.3	4702.6	2.68
			354 00 22	Sherman	174 00 33	3523.4	3853.1	2.19
Bethlehem	42 33 41.46	73 48 00.11	276 57 43	Thorp	97 00 35	5839.0	6385.3	3.63
			53 01 55	Blodgett	232 58 21	9037.5	9883.1	5.62
Houterbarrack	42 35 47.23	73 40 02.63	48 01 58	Thorp	227 59 27	6862.2	7504.3	4.26
			130 49 32	Ryesdorph	310 47 38	5082.2	5557.7	3.16
Burrill	42 39 28.40	73 43 36.02	62 16 06	Cathedral	242 14 58	2576.0	2817.1	1.60
			139 18 30	Ferris	319 17 37	2708.3	2961.7	1.68
Fish-house Branch	42 41 13.43	73 42 17.40	28 55 24	Burrill	208 54 30	3702.3	4048.7	2.30
			71 32 46	Ferris	251 31 00	3748.5	4099.2	2.33
Forbes	42 40 20.71	73 42 51.43	49 31 33	Cathedral	229 29 55	4332.7	4738.2	2.69
			98 59 03	Ferris	278 57 40	2815.6	3079.0	1.75
Van Rensselaer	42 39 00.33	73 43 18.65	143 29 20	Ferris	323 28 16	3632.5	3972.4	2.26
			82 54 55	Cathedral	262 53 35	2696.3	2948.6	1.67
East	42 37 52.74	73 44 01.05	127 19 40	Industrial School	307 18 08	3883.4	4246.8	2.41
			166 33 32	Ferris	346 32 56	5145.8	5627.2	3.20
Albany, Presbyterian church	42 39 02.68	73 44 52.82	245 35 16	Burrill	65 36 08	1920.6	2100.4	1.19
			314 23 37	Ryesdorph	134 24 59	3871.0	4233.2	2.41
Bloomingdale, 2	42 41 09.61	73 42 13.00	73 42 23	Ferris	253 40 34	3808.8	4165.2	2.37
			126 50 53	Van Aernam	306 49 35	3285.5	3592.9	2.04
De Freestville Spire	42 39 08.67	73 41 29.57	32 48 05	Ryesdorph	212 47 10	3442.3	3764.4	2.14
			119 49 56	Ferris	299 47 38	5354.1	5855.1	3.33
One Mile	42 40 28.33	73 43 52.19	279 37 45	Forbes	99 38 26	1403.2	1534.5	0.87
			348 44 11	Burrill	168 44 22	1885.3	2061.7	1.17
Toll Gate	42 41 01.84	73 43 31.13	324 31 49	Forbes	144 32 16	1557.7	1703.4	0.97
			2 12 56	Burrill	182 12 53	2885.0	3155.0	1.79
Borden's Observatory	42 42 07.53	73 41 22.12	155 19 00	Lansing	335 18 08	4196.9	4589.6	2.61
			319 15 57	Bloomingdale	139 17 15	4014.2	4389.8	2.49
Centre	42 44 02.27	73 41 17.76	98 23 28	Lansing	278 22 33	1871.8	2047.0	1.16
			303 16 56	Troy University	123 17 21	1002.8	1096.7	0.63
St. Peter	42 44 15.14	73 40 48.32	87 11 31	Lansing	267 10 16	2524.3	2760.5	1.57
			50 31 15	Van Aernam	230 28 59	5902.9	6455.3	3.67
Arsenal	42 43 15.19	73 41 55.04	241 50 44	Troy University	61 51 34	1912.8	2091.8	1.19
			57 54 54	Van Aernam	227 53 24	3585.4	3920.9	2.23
Dutch Reformed Church Spire	42 42 59.87	73 41 54.97	230 46 51	Troy University	50 47 41	2175.0	2378.5	1.35
			64 46 44	Van Aernam	244 45 13	3359.6	3674.0	2.09
St. John	42 43 30.50	73 41 20.20	244 19 06	Troy University	64 19 33	992.0	1084.8	0.62
			58 11 06	Van Aernam	238 09 12	4507.9	4929.7	2.80
Rand	42 42 21.57	73 41 27.57	86 06 11	Van Aernam	266 04 22	3671.5	4015.0	2.28
			154 16 27	Lansing	334 15 38	3752.6	4103.7	2.33
Green	42 41 26.98	73 41 59.70	116 04 10	Van Aernam	296 02 43	3263.8	3569.2	2.03
			169 56 51	Lansing	349 56 24	5143.2	5624.4	3.20
Logan's Bar	42 41 23.58	73 42 09.91	119 41 25	Van Aernam	299 40 05	3107.4	3398.2	1.93
			208 18 21	Rand	28 18 50	2032.1	2222.2	1.26
Greenbush, Roman Catholic church	42 38 24.36	73 44 01.45	163 35 16	Ferris	343 34 41	4200.5	4593.5	2.61
			221 17 13	Van Rensselaer	41 17 42	1477.3	1615.6	0.92
Greenbush Church	42 38 08.93	73 44 37.34	175 18 17	Ferris	355 18 06	4520.3	4943.2	2.81
			293 30 46	Ryesdorph	113 31 58	2632.0	2878.3	1.64
Tower	42 36 04.56	73 47 39.63	271 37 47	Hallenbeck	91 43 06	10735.3	11739.8	6.67
			37 59 57	Blodgett	217 56 09	12498.8	13668.3	7.76
Schuyler's Bridge	42 42 24.94	73 42 24.10	274 37 29	Rand	94 38 07	1290.6	1411.4	0.80
			342 45 09	Green	162 45 26	1872.4	2047.6	1.16
Hillhouse Bridge	42 41 51.68	73 42 49.86	243 46 44	Rand	63 47 40	2087.4	2282.7	1.30
			303 43 20	Green	123 43 54	1372.5	1500.9	0.85

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section II.—Hudson River—Hudson to Troy.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Wright's Bridge	42 41 26.82	73 43 06.63	206 27 24	Hill-house Bridge	26 27 36	856.7	936.8	0.53
			269 48 37	Green	89 49 22	1523.2	1665.7	0.95
Empire, Roman Catholic church	42 41 29.50	73 42 33.92	223 13 27	Rand	43 14 12	2204.8	2411.1	1.37
			275 41 19	Green	95 41 42	782.7	856.0	0.49
Shawl Factory	42 42 35.13	73 42 03.59	221 20 09	Troy University	41 21 05	2847.9	3114.3	1.77
			76 46 01	Van Aernam	256 44 36	2920.9	3194.2	1.82
West Troy, Dutch Reformed church	42 43 32.16	73 41 46.36	135 01 08	Lansing	315 00 32	1699.3	1858.3	1.05
			255 43 39	Troy University	75 44 24	1536.5	1680.3	0.96
Winslow	42 42 12.51	73 41 45.80	19 58 38	Logan's Bar	199 58 22	1606.3	1756.6	1.00
			90 31 27	Van Aernam	270 29 50	3248.2	3552.2	2.02
Mann	42 42 47.29	73 41 38.28	9 03 16	Winslow	189 03 11	1086.6	1188.3	0.68
			15 34 27	Logan's Bar	195 34 06	2681.1	2932.0	1.67

Section III.—Upper Patuxent River, Maryland.

Gilliam	38 21 20.92	76 29 56.92						
Hungerford	38 21 09.02	76 28 21.72	99 01 44	Gilliam	279 00 45	2340.0	2558.9	1.45
Peterson, 2	38 23 28.65	76 30 05.65	356 55 03	Gilliam	176 55 08	3943.7	4312.7	2.45
			329 37 19	Hungerford	149 38 24	4989.5	5456.4	3.10
Setterly Point, 2	38 22 55.65	76 31 50.36	248 10 20	Peterson, 2	68 11 25	2737.0	2993.0	1.70
			302 58 21	Hungerford	123 00 30	6037.9	6602.8	3.75
Broom's Island, 2	38 24 09.08	76 32 57.21	324 22 15	Setterly Point, 2	144 22 56	2784.8	3045.3	1.73
			286 39 15	Peterson, 2	106 41 01	4345.1	4751.7	2.70
High Bank, 2	38 23 16.27	76 33 00.84	183 05 51	Broom's Island, 2	3 05 53	1630.4	1782.9	1.01
			264 51 18	Peterson, 2	84 53 07	4268.1	4667.5	2.65
Bond	38 25 37.84	76 34 31.33	333 17 33	High Bank, 2	153 18 29	4885.5	5342.6	3.04
			320 09 21	Broom's Island, 2	140 10 19	3563.9	3897.4	2.21
Maud's Hill	38 24 38.92	76 36 03.71	299 51 18	High Bank, 2	119 53 12	5116.4	5595.1	3 18
			230 57 49	Bond	50 58 46	2884.6	3154.5	1.79
Parker	38 25 20.84	75 34 01.84	338 55 21	High Bank, 2	158 55 59	4115.9	4501.0	2.56
			66 23 34	Maud's Hill	246 22 18	3226.2	3528.1	2.00
Ayers, 2	38 26 03.92	76 35 13 87	24 46 04	Maud's Hill	204 45 33	2885.9	3155.9	1.79
			307 14 23	Parker	127 15 08	2194.2	2399.5	1.36
Reeder, 2	38 25 53.79	76 37 46.66	312 44 12	Maud's Hill	132 45 16	3400.6	3718.8	2.11
			265 10 06	Ayres, 2	85 11 41	3718.4	4066.3	2.31
Duke, 2	38 28 16.40	76 37 47.00	317 43 07	Ayres, 2	137 44 42	5519.5	6036.0	3.43
			359 53 39	Reeder, 2	179 53 39	4396.8	4808.2	2.73
McDaniel, 2	38 28 07.45	76 39 28.18	329 08 37	Reeder, 2	149 09 40	4800.1	5249.2	2.98
			263 34 32	Duke, 2	83 35 35	2468.0	2698.9	1.53
Halland's Point, 2	38 30 09.83	76 39 29.87	324 30 31	Duke, 2	144 31 35	4294.8	4696.6	2.67
			359 22 36	McDaniel, 2	179 22 37	3773.3	4126.4	2.34
Sheridan's Point	38 28 00.75	76 38 26.01	242 58 03	Duke, 2	62 58 27	1061.7	1161.1	0.66
			158 45 24	Holland's Point, 2	338 44 44	4270.0	4669.5	2.65
Washington, 2	38 30 46.42	76 41 15.36	332 04 21	McDaniel, 2	152 05 28	5546.8	6065.8	3.45
			293 48 42	Holland's Point, 2	113 49 48	2793.4	3054.8	1.74
Godg's Graces Point	38 32 24.41	76 39 44.21	355 12 51	Holland's Point, 2	175 13 00	4164.0	4553.6	2.59
			36 09 39	Washington, 2	216 08 42	3741.8	4091.9	2.32
Estep	38 31 09.29	76 41 15.51	305 36 34	Holland's Point, 2	125 37 40	3147.9	3442.4	1.96
			223 39 43	God's Graces Point	43 40 40	3202.1	3501.7	1.99
Barker	38 33 26.98	76 40 48.40	321 08 19	God's Graces Point	141 08 59	2477.0	2708.7	1.54
			8 47 39	Estep	188 47 22	4295.6	4697.5	2.67
Town Point	38 30 49.29	76 40 04.72	87 03 08	Washington, 2	267 02 24	1713.4	1873.7	1.06
			189 36 32	God's Graces Point	9 36 45	2974.5	3252.8	1.85
Stanforth	38 33 45.83	76 39 52.48	355 26 17	God's Graces Point	175 26 22	2518.4	2754.1	1.56
			66 45 27	Barker	246 44 52	1473.1	1611.0	0.92
Teneman's Point	38 34 13.89	76 40 50.31	358 10 08	Barker	178 10 09	1447.2	1582.6	0.90
			301 42 49	Stanforth	121 43 25	1645.4	1799.4	1.02
Blake	38 34 53.99	76 40 03.93	352 29 13	Stanforth	172 29 20	2119.6	2317.9	1.32
			42 14 10	Teneman's Point	222 13 41	1669.8	1826.0	1.04
Somerville, 2	38 35 40.89	76 40 41.35	4 37 10	Teneman's Point	184 37 04	2691.1	2942.9	1.67
			327 56 31	Blake	147 56 54	1706.1	1865.8	1.06

Section III.—Upper Patuxent River, Maryland.—Continued.

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Name of station.	Latitude.	Longitude.	Azimuth.	To station.	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Holland's Cliffs	38 36 31.28	76 39 54.46	4 22 14	Blake	184 22 08	3008.4	3289.9	1.87
			36 08 30	Somerville, 2	216 08 01	1923.8	2103.9	1.20
Covington	38 37 03.96	76 41 30.79	332 19 09	Blake	152 20 03	4524.8	4948.1	2.81
			293 22 29	Holland's Cliffs	113 23 29	2538.7	2776.2	1.58
Sollin	38 37 51.28	76 40 25.19	343 13 38	Holland's Cliffs	163 13 57	2576.0	2817.1	1.60
			47 24 33	Covington	227 23 52	2155.4	2357.1	1.34
Bowling's Marsh	38 37 00.66	76 40 10.51	92 00 32	Covington	272 59 42	1944.5	2126.4	1.21
			167 10 59	Sallin	347 10 50	1601.0	1750.8	1.00
High Hill	38 37 51.80	76 41 33.79	357 10 50	Covington	177 10 52	1476.7	1614.9	0.92
			270 32 52	Sallin	90 33 35	1659.2	1814.5	1.03
Lower Marlborough	38 38 49.64	76 40 42.79	346 41 26	Sallin	166 41 37	1849.3	2022.4	1.15
			34 40 05	High Hill	214 39 33	2168.4	2371.3	1.35
Magruder's Ferry	38 38 39.14	76 41 38.58	309 44 05	Sallin	129 44 51	2308.2	2524.2	1.43
			256 29 31	Lower Marlborough	76 30 06	1387.4	1517.2	0.86
Fowler	38 39 57.86	76 40 50.56	354 53 49	Lower Marlborough	174 53 54	2111.5	2309.0	1.31
			25 34 08	Magruder's Ferry	205 33 38	2690.5	2942.2	1.67
Perry	38 39 55.63	76 41 56.09	318 56 17	Lower Marlborough	138 57 03	2698.2	2950.7	1.68
			267 31 08	Fowler	87 31 49	1585.7	1734.0	0.99
Jones, 1	38 41 23.37	76 41 18.04	345 51 24	Fowler	165 51 41	2719.0	2973.4	1.69
			18 46 47	Perry	198 46 23	2857.1	3124.5	1.78
Bald Eagle	38 40 53.99	76 42 08.64	233 28 02	Jones, 1	53 28 34	1521.7	1664.1	0.95
			312 30 59	Fowler	132 31 48	2560.8	2800.4	1.59
Turton	38 42 19.31	76 41 52.75	334 04 08	Jones, 1	154 04 30	1918.0	2097.4	1.19
			8 18 22	Bald Eagle	188 18 12	2658.6	2907.4	1.65
Ravine	38 41 55.12	76 41 18.50	32 44 31	Bald Eagle	212 44 00	2240.6	2450.3	1.39
			132 02 07	Turton	312 01 46	1114.2	1218.5	0.69
Wharf Marsh	38 42 25.93	76 41 27.47	347 08 56	Ravine	167 09 02	974.5	1065.7	0.61
			71 31 18	Turton	251 31 02	643.9	704.2	0.40
Reed	38 42 52.47	76 41 45.95	331 22 48	Wharf Marsh	151 23 00	932.2	1019.4	0.58
			9 07 36	Turton	189 07 32	1035.6	1132.5	0.64
Griffith	38 43 39.64	76 41 11.67	9 32 07	Wharf Marsh	189 31 57	2304.4	2520.0	1.43
			29 39 42	Reed	209 39 21	1673.5	1830.1	1.04
Bis Jones	38 41 32.25	76 41 16.05	47 08 31	Bald Eagle	227 07 58	1734.0	1896.3	1.08
			148 34 26	Turton	328 34 03	1700.7	1859.9	1.06
Number 2	38 41 44.25	76 41 45.70	171 03 10	Turton	351 03 06	1094.6	1197.0	0.68
			297 18 01	Bis Jones	117 18 20	806.5	882.0	0.50

Section X.—Primary Points, San Francisco Bay to Tomales Bay, Drake's Bay, Tomales Bay to Slavianska River, and Monterey Harbor.

Primary Points.								
Pulgas Base, west end	37 28 39.30	122 14 17.03						
Pulgas Base, east end	37 28 26.79	122 07 09.48	92 08 22	West Base	272 04 02	10512.1	11495.7	6.53
Guano Island	37 34 14.21	122 14 44.84	356 12 51	West Base	176 13 08	10316.5	11314.6	6.43
			313 43 40	East Base	133 48 17	15482.8	16931.6	9.62
Pise Hill	37 27 34.58	122 19 37.31	264 55 53	East Base	85 03 29	18446.0	20172.0	11.46
			210 12 57	Guano Island	30 15 55	14259.4	15593.7	8.86
Red Hill	37 32 55.29	122 04 42.27	23 36 01	East Base	203 34 31	9031.4	9876.4	5.61
			99 23 38	Guano Island	279 17 31	14986.0	16388.3	9.31
Ridge	37 30 36.57	122 21 32.02	236 05 37	Guano Island	56 09 45	12037.8	13164.1	7.48
			333 19 18	Pise Hill	153 20 28	6278.0	6865.4	3.90
Rocky Mound	37 52 47.92	122 13 31.90	340 31 24	Red Hill	160 36 48	38987.0	42635.1	24.22
			16 01 50	Ridge	195 56 56	42694.1	46689.0	26.53
Table Mountain	37 55 18.12	122 34 46.79	336 51 06	Ridge	156 59 12	49646.9	54292.3	30.85
			278 20 54	Rocky Mound	98 33 57	31485.0	34431.1	19.56
Sonoma Mountain	38 19 15.36	122 33 29.51	2 26 20	Table Mountain	182 25 32	44349.5	48499.3	27.56
			329 05 45	Rocky Mound	149 18 04	56976.7	62308.0	35.40
Tomales Bay	38 10 46.18	122 55 48.50	312 49 16	Table Mountain	133 02 14	42008.2	45938.9	26.10
			244 08 26	Sonoma Mountain	64 22 15	36140.5	39522.1	22.46

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section X.—Primary Points, Drake's Bay, Tomales Bay to Slavianska River.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Ross Mountain	38 30 11.37	123 06 11.12	292 51 30	Sonoma Mountain	113 11 49	51704.3	56542.3	32.13
			337 07 23	Tomales Bay	157 13 49	38975.2	42622.1	24.22
Sulphur Peak	38 45 45.22	122 49 42.06	334 15 18	Sonoma Mountain	154 25 24	54381.9	59470.4	33.79
			39 48 13	Ross Mountain	219 37 56	37431.9	40934.4	23.26
Walalla Mount	38 51 15.61	123 28 52.47	319 42 53	Ross Mountain	139 57 04	51009.4	55782.4	31.69
			279 58 48	Sulphur Peak	100 23 21	57611.0	63001.7	35.80
Sanel Mount	38 56 46.77	123 12 02.34	350 11 06	Ross Mountain	170 14 46	49916.7	54587.4	31.02
			302 08 44	Sulphur Peak	122 22 45	38212.7	41788.3	23.74
Mount Diablo	37 52 46.19	121 53 49.61	130 24 07	Sonoma Mountain	309 59 39	75906.4	83009.0	47.16
			94 40 18	Table Mountain	274 15 09	60205.9	65839.3	37.41
Drake's Bay.								
Punta Reyes Hill	38 04 39.01	122 51 02.51	223 23 12	Sonoma Mountain	43 34 03	37232.4	40716.2	23.13
			148 25 20	Tomales Bay	328 22 24	13290.7	14534.3	8.26
Bodega Head	38 18 20.03	123 02 47.25	167 18 36	Ross Mountain	347 16 32	22482.2	24585.9	13.97
Richards	38 03 53.74	122 57 00.63	187 51 43	Tomales Bay	7 52 27	12835.6	14036.6	7.98
Punta Reyes Head	37 59 38.90	122 59 52.50	282 12 46	Table Mountain	102 28 12	37621.7	41142.0	23.38
			208 03 52	Richards	28 05 38	8901.0	9737.2	5.53
Stoele	38 02 02.14	122 53 00.78	210 46 25	Punta Reyes Hill	30 47 38	5631.9	6158.9	3.50
			66 18 40	Punta Reyes Head	246 14 27	10969.0	11995.3	6.82
Estero	38 02 02.54	122 55 38.87	234 21 23	Punta Reyes Hill	54 24 13	8286.7	9062.1	5.15
			54 26 36	Punta Reyes Head	234 24 00	7606.0	8317.7	4.73
Number 1	38 01 32.05	122 51 31.51	186 59 01	Punta Reyes Hill	6 59 19	5809.3	6352.9	3.61
			74 07 28	Punta Reyes Head	254 02 20	12707.4	13896.4	7.90
Number 2	38 00 59.08	122 49 50.20	80 30 43	Punta Reyes Head	260 24 32	14898.5	16292.6	9.26
			165 26 01	Punta Reyes Hill	345 25 16	7007.9	7663.6	4.35
Number 3	38 00 00.17	122 48 31.42	87 48 31	Punta Reyes Head	267 41 32	16628.6	18184.5	10.33
			120 09 47	Richards	300 04 33	14355.1	15698.3	8.92
Punta Reyes, east	37 59 17.49	122 56 55.86	98 45 43	Punta Reyes Head	278 43 54	4360.6	4768.7	2.71
			253 10 40	Number 2	73 15 02	10845.8	11860.6	6.74
Astronomical Station, Punta Reyes	37 59 35.04	122 57 36.06	225 38 13	Punta Reyes Hill	45 42 15	13414.0	14669.2	8.33
			257 06 57	Number 2	77 11 44	11655.4	12746.0	7.24
Punta Reyes, light-house site	37 59 39.36	123 00 13.32	210 54 08	Richards	30 56 07	9144.6	10000.2	5.68
			235 25 25	Punta Reyes Hill	55 31 04	16301.8	17827.2	10.13
Wild Cat	37 58 51.25	122 46 44.72	94 26 49	Punta Reyes Head	274 18 44	19277.5	21081.3	11.98
			121 53 39	Richards	301 47 20	17681.4	19335.8	10.99
Joyce	37 56 29.02	122 44 07.14	104 19 26	Punta Reyes Head	284 09 45	23804.0	26031.4	14.79
			126 04 27	Richards	305 56 31	23325.3	25507.8	14.49
Perrot	37 56 51.24	122 45 44.45	104 06 10	Punta Reyes Head	283 57 28	21333.0	23329.1	13.26
			128 21 41	Richards	308 14 45	21018.7	22985.4	13.06
Rock	37 45 44.76	123 04 41.14	209 41 17	Punta Reyes Hill	29 49 40	40279.2	44048.2	25.03
			247 54 02	Table Mountain	68 12 23	47294.0	51719.3	29.39
Middle Farallone	37 43 31.62	123 00 54.86	200 16 16	Punta Reyes Hill	20 22 20	41665.1	45563.7	25.89
			240 16 09	Table Mountain	60 32 11	44098.4	48224.7	27.40
North Farallone, south islet	37 45 42.92	123 04 53.55	210 01 12	Punta Reyes Hill	30 09 43	40479.5	44267.2	25.15
			247 58 23	Table Mountain	68 16 52	47596.8	52050.4	29.57
North Farallone, middle islet	37 45 52.94	123 04 59.84	210 25 41	Punta Reyes Hill	30 34 16	40290.0	44059.9	25.03
			248 23 10	Table Mountain	68 41 42	47624.8	52081.0	29.59
North Farallone, north islet	37 46 10.91	123 05 25.11	211 35 09	Punta Reyes Hill	31 43 59	40133.8	43889.2	24.94
			249 16 06	Table Mountain	69 34 54	48002.4	52494.0	29.83
Tomales Bay to Slavianska River.								
Mount Helena	38 40 02.05	122 36 59.61	66 54 01	Ross Mountain	246 35 48	46132.9	50449.6	28.66
			119 56 36	Sulphur Peak	299 48 39	21240.6	23228.1	13.20
Bodega	38 18 14.46	122 59 05.53	266 59 11	Sonoma Mountain	87 15 04	37358.9	40854.5	23.21
			340 51 51	Tomales Bay	160 53 53	14627.4	15996.1	9.09
Bodega Hill	38 22 04.13	123 02 23.49	4 46 33	Bodega Head	184 46 18	6933.5	7582.2	4.31
			325 48 46	Bodega	145 50 49	8559.0	9359.8	5.32
Ocean Beach	38 19 47.99	123 02 56.06	355 29 25	Bodega Head	175 29 30	2720.5	2975.0	1.69
			297 13 43	Bodega	117 16 06	6298.3	6887.6	3.91
Bay Beach	38 18 40.31	123 01 44.33	67 45 05	Bodega Head	247 44 26	1651.5	1806.0	1.03
			140 09 00	Ocean Beach	320 08 16	2718.2	2972.6	1.69

UNITED STATES COAST SURVEY.—GEOGRAPHICAL POSITIONS.

Section X.—Tomales Bay to Slavianska River, Monterey Harbor.

Name of station.	Latitude.	Longitude.	Azimuth.	To station—	Back azimuth.	Distance.	Distance.	Distance.
	° ′ ″	° ′ ″	° ′ ″		° ′ ″	*Metres.*	*Yards.*	*Miles.*
Astronomical Station, Bodega	38 18 20.59	123 02 17.45	272 18 28	Bodega	92 20 27	4666.3	5102.9	2.90
			178 46 53	Bodega Hill	358 46 49	6893.7	7538.7	4.28
Redwood	38 24 02.84	123 00 18.13	18 55 19	Bodega Head	198 53 46	11171.8	12217.2	6.94
			350 40 24	Bodega	170 41 09	10883.9	11902.3	6.76
Chaparral	38 29 24.76	123 09 58.12	305 09 57	Redwood	125 15 58	17212.1	18822.6	10.69
			332 56 12	Bodega Head	153 00 39	23006.4	25159.1	14.30
Benitz	38 29 51.19	123 09 53.33	307 33 13	Redwood	127 39 11	17602.3	19249.3	10.94
			322 48 46	Bodega Hill	142 53 26	18065.4	19755.8	11.23
Bodega Rock	38 17 37.87	123 01 53.75	254 33 32	Bodega	74 35 16	4239.7	4636.4	2.63
			174 58 34	Bodega Hill	354 58 16	8241.0	9012.1	5.12
Lagoon	38 18 32.86	123 00 27.79	83 20 50	Bodega Head	263 19 24	3410.9	3730.1	2.12
			156 40 45	Bodega Hill	336 39 33	7093.9	7757.7	4.41
Estero	38 17 06.92	122 58 36.83	110 20 54	Bodega Head	290 18 19	6488.5	7095.6	4.03
			161 29 10	Bodega	341 28 52	2196.1	2401.6	1.36
Inlet	38 16 19.95	122 58 05.76	118 26 51	Bodega Head	298 23 57	7777.4	8505.1	4.83
			157 38 36	Bodega	337 37 59	3817.4	4174.6	2.37
Tomales Bluff	38 14 15.36	122 58 40.17	141 29 49	Bodega Head	321 27 16	9641.7	10543.9	5.99
			175 13 18	Bodega	355 13 02	7397.3	8089.5	4.60
Sand Hill	38 20 01.55	123 02 38.40	3 55 56	Bodega Head	183 55 51	3137.3	3430.9	1.95
			302 32 34	Bodega	122 34 46	6134.4	6708.4	3.81
Dougherty's House, southwest gable	38 19 55.62	123 02 03.81	19 42 08	Bodega Head	199 41 41	3130.4	3423.3	1.95
			305 44 51	Bodega	125 46 41	5336.4	5835.7	3.32
Dr. Pigot's House, southwest gable	38 19 14.30	123 01 11.94	54 09 11	Bodega Head	234 08 12	2856.6	3123.9	1.77
			112 20 37	Ocean Beach	292 19 32	2733.8	2989.6	1.70
Salmon Creek	38 21 13.70	123 02 59.92	356 42 34	Bodega Head	176 42 42	5363.5	5865.3	3.33
			314 07 53	Bodega	134 10 19	7933.6	8675.9	4.93
Rocky Point	38 23 30.35	123 04 42.64	170 09 57	Ross Mountain	350 09 02	12548.6	13722.8	7.80
			308 11 34	Bodega Hill	128 13 00	4297.5	4699.6	2.67
Peaked Hill	38 25 44.49	123 06 06.31	179 11 25	Ross Mountain	359 11 22	8228.8	8998.7	5.11
			321 28 15	Bodega Hill	141 30 33	8682.1	9494.5	5.39
Russian River	38 27 42.82	123 07 43.06	205 56 19	Ross Mountain	25 57 16	5093.2	5569.8	3.16
			323 23 02	Bodega Hill	143 26 21	13004.9	14221.8	8.08
Dry Creek	38 28 22.68	123 08 41.10	227 18 55	Ross Mountain	47 20 28	4943.6	5406.1	3.07
			321 50 39	Bodega Hill	141 54 34	14835.9	16224.1	9.22
Monterey Harbor.								
Azimuth Point	36 35 30.91	121 51 52.54						
Rocky Point	36 36 49.14	121 52 44.34	331 53 59	Azimuth Point	151 54 30	2733.4	2989.1	1.70
Sand Hill	36 36 07.76	121 51 15.94	38 41 13	Azimuth Point	218 40 51	1455.1	1591.3	0.90
			120 08 57	Rocky Point	300 08 04	2540.0	2777.6	1.58
Monterey Bay	36 37 35.93	121 49 30.67	43 54 41	Sand Hill	223 53 38	3771.8	4124.8	2.34
			73 19 49	Rocky Point	253 17 54	5023.1	5493.2	3.12
Astronomical Station	36 37 59.29	121 54 25.00	306 10 54	Sand Hill	126 12 47	5820.8	6365.4	3.62
			275 35 55	Monterey Bay	95 38 51	7346.9	8034.4	4.56
West Base	36 36 03.48	121 52 10.20	264 24 15	Sand Hill	84 24 47	1354.8	1481.6	0.84
			148 55 29	Rocky Point	328 55 09	1643.3	1797.1	1.02
Round Hill	36 33 49.89	121 51 27.97	202 41 43	Monterey Bay	22 42 53	7552.2	8258.9	4.69
			161 02 40	Rocky Point	341 01 55	5841.7	6388.3	3.63

APPENDIX No. 16.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART X.—ANALYSIS OF THE DISTURBANCES OF THE DIP AND TOTAL FORCE. BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY OF SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.

[From the Smithsonian Contributions to Knowledge.]

Analysis of the disturbances of the dip and total force.

In the preceding discussion of the disturbances of the horizontal and vertical components of the magnetic force at the Girard College observatory, the laws of their variations, as far as they have been recognizable from the series, were brought out and discussed, and this suffices, perhaps, in most cases, for any future application of theory, or for the purpose of testing hypotheses. But as it is also desirable for other comparisons to deduce the corresponding results for dip and total force from previous researches, it is proposed here to present the results of this combination numerically and in tabular form.

The combination is effected by the formulæ—

$$\Delta\theta = \sin\theta\cos\theta\left(\frac{\Delta Y}{Y} - \frac{\Delta X}{X}\right) \text{ and } \frac{\Delta\varphi}{\varphi} = \sin^2\theta\frac{\Delta Y}{Y} + \cos^2\theta\frac{\Delta X}{X},$$

which expressions have already been used in the preceding part.

A strict treatment of the disturbances of either the dip or total force would require the formation of the difference of each observation of the vertical and horizontal force from its normal value, (corresponding to the hour, month, and year,) the conversion of these differences from units of scale value into parts of the respective force, and, finally, the numerical combination of the contemporaneous values of the two instruments, by means of the above formulæ. To treat over 44,000 observations in this manner is impracticably laborious, and makes it desirable to substitute in its place another process less cumbrous, but, as regards results, equally effective. The method adopted avoids also the labor of forming normals, and especially that of separating the disturbances anew for each element. The method pursued in the discussion of the Toronto observations answer all purposes, and has been adopted for the Philadelphia series. A more distinct idea, however, is here given for the limiting value, beyond which disturbances are recognized. The method is as follows: Returning to the manuscript tables which contain the observations reduced to a uniform temperature and corrected for progressive change, as far this was practicable, each observation marked there as a disturbance—that is, which differed as much or more than ± 30 scale divisions from the normal of the vertical force, and as much or more than ± 33 from the normal of the horizontal force—was transcribed, and at once converted into its equivalent in parts of the force to which it respectively belonged. One scale division of the vertical force magnetometer equals 0.000033 parts, and of the horizontal force magnetometer 0.0000365 parts, of the respective force. These disturbances of the two components were tabulated in chronological order; and when for any entry but one of the constituent parts appeared disturbed, the corresponding difference from the normal of the contemporaneous second part, whatever amount that might be, was likewise entered in an adjoining column. The corresponding values of $\Delta\theta$ and $\frac{\Delta\varphi}{\varphi}$ were then easily computed for each disturbance, whether it occurred in both components or in one only. Trustworthy contemporaneous readings of the two magnetometers commence with February, 1841, and continues to the close of the series, in June, 1845. There is, however, an interval of time between the readings of the instruments, which we are obliged to disregard—it amounts to but five minutes—the bifilar magnetometer having been read so much later.

As there is not generally a contemporaneous disturbance in the vertical and horizontal force, the total number of disturbed values obtained by the process explained above and employed is necessarily much greater than it was for either of the components. It becomes, therefore, necessary to fix upon some limit of recognition for a disturbed value of the dip and also of the total force. This is best done by the adoption of that value which will separate an equal proportion of disturbed values from the total number, as was done in the components. For the vertical component, one in every 10.5 observations; for the horizontal component, one in every 19.3 observations, was separated as a disturbed value between February 1, 1841, and June 30, 1845; on the average, therefore, one in every 15 observations should be separated in the dip and total force series. During the time mentioned the number of observations of vertical force was 22,092, and of horizontal force 22,150, from which we should accordingly derive nearly 1,470 disturbances. Now the number of computed values of $\Delta\theta$ and of $\frac{\Delta\varphi}{\varphi}$ is 2,362; hence, marking in each set the 1,470 highest values, the limit of $\pm 1.'1$ is reached in the dip and ± 0.00094 in the total force, which constitute the limiting values at and beyond which disturbances are recognized in each element. To render the series of disturbance results homogeneous, the disturbances at the odd hours after October, 1843, have been omitted. At Toronto the limit for the recognition of disturbances in the dip* was $1.'0$, and in the total force 0.0004, parts of the force.

Analysis of the disturbances of the inclination.

The number of values of inclination differing $\pm 1.'1$ or more from their normal amount, and which constitute the disturbance values, is 1,446. These are variously combined in the following tables, and, when necessary, are separated into two classes—those which increase and those which decrease the inclination. To the former the sign + is prefixed; to the latter the sign —. The aggregate and mean amount of disturbances are expressed in minutes of arc. The columns containing the number of disturbances are headed with the letter *n*. When ratios are given, they exhibit the proportion of the amount of disturbances during any given sub-period to the average amount of disturbances during the whole period. In the first and three subsequent tables the values for the first five months of 1841 are omitted, as there are no adequate means of extending the series beyond four full years.

TABLE I.—*Aggregate amount and number of disturbances of the inclination in each month, divided into disturbances, which increase and which decrease the inclination.*

Month.	1841 and 1842.				1842 and 1843.				1843 and 1844.			
	+	*n.*	—	*n.*	+	*n.*	—	*n.*	+	*n.*	—	*n.*
	′		′		′		′		′		′	
July	24.5	16	15.7	10	31.5	17	17.2	9	16.9	10	4.4	3
August	34.5	16	14.0	9	13.6	8	33.5	22	20.8	13	0.0	0
September	104.7	40	14.4	10	20.7	9	114.8	64	8.4	4	7.2	6
October	69.7	32	13.6	9	19.5	11	40.2	27	7.2	4	10.1	6
November	79.9	31	12.4	5	35.2	16	6.8	4	9.9	7	3.9	3
December	75.5	36	27.2	18	12.4	8	9.5	6	29.6	20	4.9	4
January	72.3	33	40.5	24	(50.7)	(27)	(23.2)	(14)	29.1	21	5.9	4
February	101.6	45	40.3	26	(57.6)	(26)	(22.2)	(14)	13.7	8	4.2	3
March	31.6	17	27.0	16	(37.5)	(20)	(18.6)	(12)	43.4	24	10.3	8
April	52.2	26	14.2	10	56.0	30	17.4	10	29.5	20	12.0	6
May	41.1	25	30.5	15	39.7	18	34.5	18	7.9	4	1.6	1
June	39.9	21	21.8	13	9.1	7	20.7	11	1.4	1	5.9	4

The values in parentheses for January, February and March are interpolated, and are the average values of the corresponding months of the year preceding and the year following.

Month.	1844 and 1845.				Sums, 1841 to 1845.				Ratio.	
	+	*n.*	—	*n.*	+	*n.*	—	*n.*	+	—
	′		′		′		′			
July	1.1	1	12.8	8	74.0	44	50.1	30	0.55	0.73
August	42.4	29	3.9	3	111.3	66	51.4	34	0.83	0.75
September	25.4	14	10.9	6	159.2	67	147.3	86	1.19	2.15
October	10.0	7	21.8	11	106.4	54	85.7	53	0.79	1.25
November	40.3	19	1.5	1	165.3	73	24.6	13	1.24	0.35
December	31.7	17	37.3	20	149.2	81	78.9	48	1.12	1.15
January	23.7	10	7.7	5	175.8	91	77.3	47	1.31	1.12
February	5.8	3	0.0	0	178.7	82	66.7	43	1.34	0.97
March	19.1	13	5.5	4	131.6	74	61.4	40	0.99	0.92
April	29.4	17	6.6	4	167.1	93	50.2	30	1.25	0.73
May	22.0	10	4.7	3	110.7	57	71.3	37	0.83	1.04
June	23.8	17	8.8	5	74.2	46	57.2	33	0.56	0.84

* Vol. iii, p. xliii.

It would appear that during the colder season both sets of ratios present greater values. Between September and February, inclusive, this ratio is on the average 1.16, and in the other months it is 0.84. Of the ratios decreasing the inclination, the September and November values are somewhat anomalous—the first too high, the second too low.

The following table gives the annual inequality of the disturbances, irrespective of their sign:

TABLE II.—*Aggregate amount and number of disturbances of the inclination in each month.*

	Sum.	*n.*	Ratio.
July	124.1	74	0.62
August	162.7	100	0.80
September	306.5	153	1.51
October	192.1	107	0.95
November	189.9	86	0.94
December	228.1	129	1.13
January	253.1	138	1.25
February	245.4	125	1.22
March	193.0	114	0.96
April	217.3	123	1.07
May	182.0	94	0.90
June	131.4	79	0.65

The series comprises the four years between July, 1841, and July, 1845. The ratio is that of the sums.

The ratio near the autumnal equinox is the greatest of all; that about the vernal equinox is a little below the average value. The least value occurs, probably, near the summer solstice.

TABLE III.—*Aggregate amount and number of disturbances of the inclination in the different years of observation.*

Year.	Sum.	*n.*	Ratio.
1841–'42	999.1	503	1.65
1842–'43	742.1	408	1.22
1843–'44	288.2	184	0.47
1844–'45	396.2	227	0.66

The ratios exhibit the variation due to the eleven-year inequality.

The minimum amount of disturbances in the eleven-year circle therefore occurred in the beginning of 1844.

TABLE IV.—*Aggregate amount and number of disturbances in each year, arranged for disturbances increasing the inclination and for those decreasing it, together with the ratios of the sums.*

Year.	Sum. +	*n.*	Sum. −	*n.*	Ratio. +	Ratio. −
1841–'42	727.5	338	271.6	165	1.81	1.32
1842–'43	383.5	197	358.6	211	0.96	1.74
1843–'44	217.8	136	70.4	48	0.55	0.35
1844–'45	274.7	157	121.5	70	0.68	0.59

The minimum of the eleven-year period is equally well marked in the disturbances increasing and in those decreasing the inclination. The sum of the positive values (1,603.′5) is to the sum of the negative values, (822.′1,) as 1.95 to 1. At Toronto, between 1844 and 1848, this ratio was 5.6 to 1. The ratio, however, increased from 2.7 to 8.5 to 1 during this time.

In Tables V and VI, which exhibit the diurnal inequality of the disturbances, the whole series between February, 1841, and June, 1845, is employed. The sums, numbers, and ratios given do not in strictness apply to the even hours, but to an epoch 20 minutes later.

TABLE V.—*Aggregate amount and number of disturbances of the inclination, distributed over th eeven hours of the day, and ratio, showing the diurnal inequality of the sun.*

Hour.	Sum.	n.	Ratio.
0	244.8	143	1.11
2	183.2	110	0.83
4	184.1	111	0.84
6	170.8	98	0.78
8	154.8	94	0.70
10	213.6	116	0.99
Noon	250.7	141	1.14
14	260.9	131	1.19
16	232.4	130	1.06
18	245.0	126	1.11
20	253.6	121	1.16
22	238.0	125	1.09

The hourly disturbances of the inclination exhibit a regular progression—between 1 a. m. and 11 a. m. the numbers fall short of the mean hourly value, and during the remaining afternoon and night hours they exceed this average value. The minimum occurs near 8 a. m., and the maximum near 8 p. m. There is, however, an indication of a superimposed smaller progression, which, owing to the short series of observation, is not distinctly brought out. At Toronto we have a double progression, and the above ratios approximate to it. At Philadelphia a secondary maximum probably occurs about noon, and a secondary minimum about 4 p. m.

Table VI shows the ratios at the different hours for disturbances increasing and disturbances decreasing the inclination.

TABLE VI.—*Aggregate amount and number of hourly disturbances of the inclination for increasing and decreasing values, and mean effect of disturbances.*

Hour.	Sum.	n.	Sum.	n.	Ratio of sum.		Excess of increasing disturbances.	Average diurnal effect of disturbances.
	+		—		+	—		
	′		′				′	′
0	163.9	94	80.9	49	1.15	1.06	+ 83.0	+ 0.06
2	101.7	61	81.5	49	0.71	1.06	+ 20.2	+ 0.02
4	82.4	51	101.7	60	0.58	1.33	— 19.3	— 0.02
6	97.1	57	73.7	41	0.68	0.96	+ 23.4	+ 0.02
8	97.8	58	57.0	36	0.69	0.74	+ 40.8	+ 0.03
10	130.2	64	83.4	52	0.91	1.09	+ 46.8	+ 0.04
Noon	139.3	75	111.4	66	0.98	1.45	+ 27.9	+ 0.02
14	193.2	90	67.7	41	1.35	0.89	+ 125.5	+ 0.10
16	148.5	79	83.9	51	1.04	1.09	+ 64.6	+ 0.05
18	178.7	86	66.3	40	1.25	0.87	+ 112.4	+ 0.09
20	198.3	87	55.3	34	1.39	0.72	+ 143.0	+ 0.11
22	181.5	91	56.5	34	1.27	0.74	+ 125.0	+ 0.10

The disturbances which increase the inclination show a very regular single progression, the value at 2 p. m. only being slightly anomalous; their minimum occurs at 4 a. m., and their maximum at 8 p. m. The disturbances decreasing the inclination are small in number at all hours, and show a tendency at double progression—principal maximum about noon, principal minimum about 8 p. m., secondary maximum about 4 a. m., and secondary minimum about 8 a. m. At Toronto the results appear different; but it is absolutely necessary for effective comparison to have results from contemporaneous series. As at Toronto, the disturbances increasing the inclination greatly preponderate over those decreasing it. The accumulated effect of this difference is shown in the column headed "excess," (Table VI.) At the hour 4 a. m. alone we find the increasing disturbances inferior; at the hour 8 p. m. the difference has reached its maximum. At Toronto this maximum occurred an hour or two after midnight. The last column of Table VI exhibits the average diurnal effect of the disturbances, (exceeding 1.′1, their normal value,) the plus sign indicating a preponderance of increasing dip. The number of days is 1,297.

The distribution of the disturbances according to their magnitude, for an equal increase of 1′, is as follows:

Between	No. of disturbances.
1.′1 and 2.′1	1096
2.1 and 3.1	247
3.1 and 4.1	65
4.1 and 5.1	27
5.1 and 6.1	5
6.1 and 7.1	3
7.1 and 8.1	3
Beyond	None.

Analysis of the disturbances of the total force.

The number of values of total force differing 0.00094 parts of the force from its normal amount, and which constitute the disturbance values, is 1,470, which have been combined in a manner similar to that of the disturbances of the dip. An increasing total force is indicated by a + sign; a decreasing one by a — sign. The aggregate amount and mean amount of disturbances are expressed in parts of the force, and the letter n indicates the number of disturbances. In the tables of the annual inequality the series commences with July, 1841; in those of the diurnal inequality it commences with February, 1841. The ratios given are those of the aggregate amount.

TABLE VII.—*Aggregate amount and number of disturbances of the total force in each month, divided into disturbances which increase and which decrease the force.*

Month.	1841 and 1842.				1842 and 1843.				1843 and 1844.			
	+	$n.$	—	$n.$	+	$n.$	—	$n.$	+	$n.$	—	$n.$
July	.02944	25	.04552	32	.01115	8	.02518	15	.00000	0	.00377	3
August	.01239	10	.00438	4	.00758	5	.02658	24	.00830	8	.00200	2
September	.01759	15	.02807	19	.02395	16	.06228	42	.01355	10	.00734	7
October	.02658	20	.00697	6	.01148	10	.00410	4	.00663	5	.00585	5
November	.02357	17	.02413	20	.00781	6	.00960	9	.01563	13	.02485	21
December	.07598	47	.05026	35	.00715	7	.00898	7	.03267	28	.00645	6
January	.06321	38	.04939	36	(.04792)	(32)	(.03222)	(24)	.03264	27	.01506	13
February	.07043	50	.03481	28	(.04151)	(30)	(.01984)	(16)	.01259	10	.00486	4
March	.01895	15	.02730	19	(.02711)	(22)	(.02574)	(19)	.03527	29	.02419	19
April	.04122	28	.02820	19	.03523	24	.02084	18	.02181	19	.01940	1
May	.04586	27	.02443	16	.02697	17	.01736	14	.00977	6	.00000	0
June	.02777	21	.01191	11	.00561	3	.01038	7	.00342	3	.02193	20

The values in parentheses for January, February, and March, are interpolated, and are the average values of the corresponding months of the year preceding and the year following.

Month.	1844 and 1845.				Sums, 1841—1845.				Ratio.	
	+	n.	—	n.	+	n.	—	n.	+	—
July	.00805	8	.01076	9	.04864	41	.08523	59	0.56	1.28
August	.04661	35	.01348	10	.07488	58	.04644	40	0.87	0.70
September	.00715	5	.00108	1	.06224	46	.09877	69	0.72	1.48
October	.00331	3	.00809	5	.04800	38	.02501	20	0.56	0.38
November	.00000	0	.00100	1	.04701	36	.05958	51	0.54	0.89
December	.01365	12	.00416	4	.12945	94	.06985	52	1.50	1.05
January	.00210	2	.00543	4	.14587	99	.10210	77	1.68	1.53
February	.00000	0	.00216	2	.12453	90	.06167	50	1.44	0.92
March	.02489	20	.01231	11	.10622	86	.08954	68	1.23	1.34
April	.00513	4	.00463	3	.10339	75	.07307	54	1.20	1.10
May	.02511	12	.00211	2	.10771	62	.04390	32	1.24	0.65
June	.00270	2	.00108	1	.03950	29	.04530	39	0.46	0.68

The ratios of the increasing disturbances of the force have a double progression, as have also those of the decreasing disturbances, though not so well marked. Increasing disturbances show a principal maximum in January, a principal minimum in June, and a secondary maximum and minimum in August and November, respectively. Decreasing disturbances show a principal maximum in January, a principal minimum in October, and a secondary maximum and minimum in September and May, respectively. It appears, therefore, that, upon the whole, we observe the same laws as at Toronto, viz: the disturbances increasing the force and those decreasing the force follow the same progressive monthly change, and exhibit maximum values about the equinoxes and minimum values about the solstices. This last remark also applies to the results of the following table, in which the annual inequality of the disturbances is given, irrespective of sign.

TABLE VIII.—*Aggregate amount and number of disturbances of the total force in each month, and ratio of sums.*

	Sum.	n.	Ratio.
July	0.13387	100	0.87
August	0.12132	98	0.79
September	0.16101	115	1.05
October	0.07301	58	0.47
November	0.10659	87	0.70
December	0.19930	146	1.30
January	0.24797	176	1.62
February	0.18620	140	1.22
March	0.19576	154	1.28
April	0.17646	129	1.15
May	0.15161	94	0.99
June	0.08480	68	0.56

TABLE IX.—*Aggregate amount and number of disturbances of the total force in the different years of observation.*

Year.	Sum.	n.	Ratio.
1841–'42	.78836	558	1.72
1842–'43	.51657	379	1.13
1843–'44	.32798	272	0.71
1844–'45	.20499	156	0.44

The ratios of the sums exhibit part of the eleven year inequality.

The minimum of the eleven-year period, according to the above ratio, occurred, probably, in 1845.

TABLE X.—*Aggregate amount and number of disturbances in each year (July to July) arranged for disturbances increasing and disturbances decreasing the force, with ratios of sums.*

Year.	Sum.	*n.*	Sum.	*n.*	Ratio.	
	+		—		+	—
1841–'42	.45299	313	.33537	245	1.75	1.67
1842–'43	.25347	180	.26310	199	0.98	1.32
1843–'44	.19228	158	.13570	114	0.74	0.68
1844–'45	.13870	103	.06629	53	0.53	0.33

The inequality of the eleven-year period is equally well marked for disturbances increasing and for disturbances decreasing the total force. The sum of the positive values is 1.03744, and of the negative value, 0.80046. Increasing disturbances are, therefore, preponderating in the ratio of 1.3 to 1. In the years 1842–'43, however, decreasing disturbances were in excess over increasing ones; and at Toronto, between 1844 and 1848, the general effect of the larger disturbances of the force was to decrease the total magnetic force more than to increase it. The excess in the different years appears to be rather irregular.

The following tables exhibit the diurnal inequality of the disturbances. The whole series, beginning with February, 1841, is employed. The sums, numbers, and ratios given apply to an epoch 20 minutes later than indicated by the tables.

TABLE XI.—*Aggregate amount and number of disturbances of the total force, distributed over the even hours of the day, and ratio showing the diurnal inequality of the sum.*

Hour.	Sum.	*n.*	Ratio.
0	.19733	150	1.19
2	.20046	148	1.22
4	.20018	148	1.21
6	.17163	121	1.04
8	.13858	106	0.84
10	.13691	105	0.83
Noon	.15058	115	0.92
14	.19949	144	1.21
16	.14958	116	0.91
18	.13974	103	0.85
20	.13176	97	0.80
22	.16077	117	0.98

The hourly disturbances exhibit a regular double progression, with a principal maximum at 2 a. m. and a principal minimum at 8 p. m.; also a secondary maximum about 2 p. m. and a secondary minimum about 10 a. m. At Toronto these hours were, respectively, 3 a. m., 11 a. m., and 5 p. m., 9 p. m., showing an exchange of the hours of the principal and secondary minimum. The disturbance at the hour of maximum is about eleven times greater than at the minimum hour; whereas this proportion is but one and a half to one at Philadelphia.

TABLE XII.—*Aggregate amount and number of hourly disturbances of the total force for increasing and decreasing values, ratios, and mean effect of disturbances.*

Hour.	Sum. +	n.	Sum. —	n.	Ratio of sum. +	Ratio of sum. —	Difference of sums.	Average diurnal effect.
0	.10570	83	.09163	67	1.22	1.18	+ .01407	+ .000011
2	.08589	68	.11457	80	0.99	1.47	— .02868	— .000022
4	.08264	66	.11754	82	0.95	1.51	— .03490	— .000027
6	.08449	57	.08714	64	0.97	1.12	— .00265	— .000002
8	.06261	48	.07597	58	0.72	0.97	— .01336	— .000010
10	.06364	46	.07327	59	0.73	0.94	— .00963	— .000008
Noon	.07094	51	.07964	64	0.82	1.02	— .00870	— .000007
14	.13083	86	.06866	58	1.50	0.88	+ .06217	+ .000049
16	.08664	66	.06294	50	1.00	0.81	+ .02370	+ .000018
18	.08880	64	.05094	39	1.02	0.66	+ .03786	+ .000029
20	.08223	60	.04953	37	0.95	0.64	+ .03270	+ .000025
22	.09791	71	.06286	46	1.13	0.80	+ .03505	+ .000027

The ratios of the increasing and decreasing disturbances appear to follow the same law—that is, the values at any hour appear to be complementary to one another, a high plus value corresponding to a low minus value. The phenomenon is, however, not so distinctly brought out as from the longer series at Toronto. The last two columns contain the differences of the sums at each hour, and the average effect of the larger disturbances of the total force. From 1 p. m. to 1 a. m. the larger disturbances augment the total force; from 1 a. m. to 1 p. m. they diminish it. Greatest augmentation at 2 p. m.; greatest diminution at 4 a. m. The greatest augmentation is nearly twice as great as the greatest diminution; whereas, at Toronto the opposite effect was observed.

The distribution of the disturbances of the total force according to their magnitude, for an equal increase of .00090 parts of the force, is as follows:

Between	No. of disturbances.
.00094 and .00184	1324
.00184 and .00274	122
.00274 and .00364	17
.00364 and .00454	4
.00454 and .00544	2
.00544 and .00634	0
.00634 and .00724	1
Beyond	None.

APPENDIX No. 17.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART XI.—SOLAR-DIURNAL VARIATION AND ANNUAL INEQUALITY OF THE INCLINATION AND TOTAL FORCE, WITH DIAGRAMS, (SEE PLATE No. 38.) BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY OF SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.

[From the Smithsonian Contributions to Knowledge.]

Solar-diurnal variation of the dip and total force.

To make the combination of the horizontal and vertical-force components complete, there remains the discussion of the regular solar-diurnal variation and its annual inequality of the resulting dip and total force.

Table III, of Part V, contains the solar-diurnal variation, expressed in parts of the force, of the horizontal component freed from the larger disturbances. Table III, of Part VIII, contains similar information with regard to the vertical component. The numbers of these tables, however, cannot be combined directly, owing to the eleven-year inequality, which requires that the two sets of components should cover precisely the same interval of time In the present case the table of the horizontal force extends from July, 1840, to July, 1845, a five-year series; whereas the table of the vertical force extends over four years only. A new table of monthly normals of the horizontal component was therefore prepared, in which the first year's observations were omitted. This was done by the same method as had been followed in the preparation of the former annual values of Part V. The following table differs from that of Table I, of Part V, only in the number of observations employed, and extends from July, 1841, to July, 1845:

TABLE I.—*Recapitulation of the hourly normals of the horizontal force (expressed in scale divisions) for each month of the year, and for summer, winter, and the whole year, between July,* 1841, *and July,* 1845.

1841—'45.	0*h*.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11*h*.	+ 21½*m*.
July	791	790	789	788	787	786	785	788	796	803	806	804	....
August	813	813	813	812	811	809	808	815	825	835	837	830	....
September	829	827	830	829	826	824	821	830	842	850	853	852	....
October	850	846	847	845	844	844	844	848	854	860	865	864	....
November	853	852	850	849	848	846	845	849	853	859	862	865	....
December	883	879	878	877	874	873	871	872	874	878	885	892	....
January	905	902	902	901	899	899	899	898	900	908	914	918	....
February	915	914	913	912	910	908	906	908	910	914	920	922	....
March	919	917	915	915	915	913	912	915	920	927	931	936	....
April	945	944	944	942	940	938	938	940	948	958	965	966	....
May	947	946	944	942	942	940	938	944	954	961	960	956	....
June	972	972	972	972	969	966	962	968	973	980	983	980	....
Year	885.2	883.5	883.1	882.0	880.4	878.8	877.4	881.2	887.4	894.4	898.4	898.8	....
Summer	882.8	882.0	882.0	880.8	879.2	877.2	875.3	880.8	889.7	897.8	900.7	898.0	....
Winter	887.5	885.0	884.2	883.2	881.7	880.5	879.5	881.7	885.2	891.0	896.2	899.5	....

The summer months comprise April to September, inclusive; the winter months comprise October to March, inclusive. One scale division equals 0.0000365 parts of the force. Increasing numbers denote decrease of force.

1841—'45.	12h. (noon.)	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23h.	+ 21½m.
July	797	788	782	780	779	783	788	791	793	793	793	793	....
August	820	811	803	802	804	809	815	816	817	816	816	815	....
September	844	834	829	828	828	832	834	834	832	834	832	832	....
October	866	860	856	854	854	854	854	854	855	853	853	852	....
November	861	858	853	852	851	853	851	851	852	852	853	853	....
December	894	889	885	880	878	878	879	880	882	884	884	883	....
January	916	909	905	900	899	902	905	905	904	905	905	904	....
February	925	920	915	912	915	915	916	919	921	917	915	915	....
March	934	930	923	918	921	923	924	923	921	920	921	920	....
April	960	957	947	944	943	944	948	948	949	950	947	947	....
May	951	943	938	938	938	939	945	947	949	949	948	945	....
June	974	969	962	961	961	965	970	971	971	972	973	973	....
Year	895.2	889.0	883.2	880.7	880.9	883.1	885.7	886.5	887.2	887.1	886.7	886.0	....
Summer	891.0	883.7	876.8	875.5	875.5	878.7	883.3	884.5	888.2	885.7	884.8	884.2	....
Winter	899.3	894.0	889.5	886.0	886.3	887.5	888.2	888.7	889.2	888.5	888.5	887.8	....

Subtracting each value from its respective monthly mean value, and converting these differences into parts of the force, we obtain the numbers of Table II; a plus sign indicates a greater force than the normal value, a minus sign a smaller one. The first three decimals are placed at the head of the table.

TABLE II.—*Regular solar-diurnal variation of the horizontal force between July 1841 and July 1845*

Values of $\frac{\Delta X}{X}$.

0.000

1841–'45.	0h.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11h.	+ 21½m.
January	−025	+085	+085	+121	+194	+194	+194	+231	+158	−134	−353	−499	....
February	−005	+032	+068	+105	+178	+251	+324	+251	+178	+032	−186	−259	....
March	+087	+160	+233	+233	+233	+306	+342	+233	+050	−205	−351	−534	....
April	+110	+146	+146	+219	+292	+365	+365	+292	000	−365	−620	−657	....
May	−036	000	+073	+146	+146	+219	+292	+073	−292	−547	−511	−365	....
June	−056	−056	−056	−056	+054	+163	+309	+090	−092	−348	−457	−348	....
July	−017	+019	+056	+092	+129	+165	+202	+092	−200	−455	−565	−492	....
August	+080	+080	+080	+117	+153	+226	+263	+007	−358	−723	−796	−540	....
September	+168	+241	+131	+168	+277	+350	+460	+131	−307	−599	−708	−672	....
October	+116	+262	+225	+298	+335	+335	+335	+189	−030	−249	−435	−395	....
November	000	+035	+109	+145	+181	+256	+291	+145	000	−220	−329	−439	....
December	−091	+055	+091	+128	+237	+274	+347	+310	+237	+091	−164	−420	....
Year	+027	+088	+103	+143	+201	+259	+310	+171	−055	−310	−456	−469	....
Summer	+043	+072	+072	+116	+174	+247	+317	+116	−209	−505	−610	−512	....
Winter	+014	+105	+134	+171	+226	+269	+305	+225	+098	−114	−303	−424	....

1841–'45.	12h. (noon.)	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23h.	+ 21½m.
January	−427	−171	−025	+158	+194	−085	−025	−025	+011	−025	−025	+012	....
February	−370	−186	−005	+105	−005	−005	−042	−151	−224	−078	−005	−005	....
March	−461	−315	−059	+123	+014	−059	−096	−059	+014	+050	+014	+050	....
April	−438	−328	+036	+146	+182	+146	000	000	−036	−073	+036	+036	....
May	−182	+109	+292	+292	+292	+256	+036	−036	−109	−109	−073	+036	....
June	−129	+054	+309	+346	+346	+200	+017	−019	−019	−056	−092	−092	....
July	−236	+092	+311	+384	+421	+275	+092	−017	−090	−090	−090	−090	....
August	−175	+153	+445	+482	+409	+226	+007	−029	−066	−029	−029	+007	....
September	−380	−015	+168	+204	+204	+058	−015	−015	+058	−015	+058	+058	....
October	−468	−249	−103	−030	−030	−030	−030	−030	−067	+006	+006	+043	....
November	−293	−183	000	+035	+072	000	+072	+072	+035	+035	000	000	....
December	−493	−310	−164	+018	+091	+091	+055	+018	−055	−128	−128	−091	....
Year	−338	−112	+100	+189	+183	+103	+006	−023	−046	−043	−028	−003	....
Summer	−257	+011	+262	+309	+309	+192	+025	−019	−044	−063	−030	−008	....
Winter	−416	−236	−059	+068	+057	+014	−012	−030	−048	−023	−023	+004	....

To render the preceding table uniform with the similar one of the vertical component, the values at the odd hours will hereafter be dropped. Their weight is less than one-half of that of the even hours. The small difference in the times ($0.^{m}9$) will be disregarded, and the values of the dip and total force, immediately deduced from the horizontal and vertical components, will refer to an epoch $21.^{m}1$ after the full hour.

For greater completeness Table III, of Part VIII, is here inserted.

TABLE III.—*Regular solar-diurnal variation of the vertical force between July*, 1841, *and July*, 1845.

Values of $\frac{\Delta Y}{Y}$.

1841 to 1845.	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. +20.6.
January	— 059	+ 238	+ 040	— 026	— 026	+ 172	+ 172	+ 304	— 092	— 323	— 224	— 158	....
February	— 198	+ 033	— 132	— 165	+ 099	+ 231	+ 264	+ 396	+ 198	— 264	— 330	— 132	....
March	— 178	+ 086	— 046	— 112	+ 086	+ 119	+ 251	+ 317	+ 020	— 178	— 145	— 211	....
April	— 353	— 155	— 122	— 023	+ 175	+ 274	+ 274	+ 340	+ 241	— 023	— 320	— 320	....
May	— 412	— 346	— 214	+ 049	+ 247	+ 280	+ 346	+ 445	+ 313	+ 016	— 313	— 412	....
June	— 528	— 297	— 198	— 033	+ 198	+ 396	+ 594	+ 462	+ 363	— 066	— 429	— 462	....
July	— 571	— 406	— 241	+ 056	+ 221	+ 419	+ 584	+ 551	+ 386	— 043	— 406	— 538	....
August	— 485	— 386	— 287	— 089	+ 109	+ 406	+ 736	+ 571	+ 340	— 023	— 386	— 485	....
September	— 469	— 304	— 271	— 205	+ 092	+ 323	+ 521	+ 521	+ 356	+ 026	— 271	— 337	....
October	— 099	+ 066	000	— 099	+ 231	+ 198	+ 198	+ 198	— 033	— 198	— 264	— 198	....
November	— 043	— 043	— 142	— 109	+ 086	+ 122	+ 254	+ 221	— 010	— 076	— 109	— 109	....
December	— 059	+ 139	+ 040	— 059	+ 040	+ 139	+ 205	+ 205	— 092	— 290	— 191	— 125	....
Year	— 287	— 115	— 131	— 068	+ 129	+ 257	+ 366	+ 377	+ 165	— 121	— 282	— 290	....
Summer	— 469	— 317	— 221	— 040	+ 175	+ 350	+ 508	+ 482	+ 333	— 020	— 353	— 426	....
Winter	— 106	+ 086	— 040	— 096	+ 082	+ 162	+ 224	+ 274	000	— 221	— 211	— 155	....

Solar-diurnal variation of the inclination.

The combination of the component values $\frac{\Delta X}{X}$ and $\frac{\Delta Y}{Y}$ to form the corresponding values of the dip is effected by the formula $\Delta\theta = \sin\theta\cos\theta\left(\frac{\Delta Y}{Y} - \frac{\Delta X}{X}\right)$.

$\Delta\theta$ will be expressed in minutes. $\theta = 71° 59'$. A plus sign indicates an augmentation of the north dip; a minus sign the converse.

TABLE IV.—*Regular solar diurnal variation of the dip between July*, 1841, *and July*, 1845. *Values of* $\Delta\theta$.

1841 to 1845.	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. +21.1.
	′	′	′	′	′	′	′	′	′	′	′	′	
January	—0.03	+0.15	—0.16	—0.22	—0.19	+0.53	+0.61	+0.33	—0.30	—0.31	—0.24	—0.13	....
February	—0.20	—0.04	—0.32	—0.50	—0.08	+0.42	+0.63	+0.40	+0.20	—0.22	—0.11	—0.13	....
March	—0.27	—0.15	—0.28	—0.46	+0.04	+0.48	+0.72	+0.38	+0.01	—0.08	—0.16	—0.23	....
April	—0.47	—0.30	—0.41	—0.39	+0.18	+0.91	+0.73	+0.31	+0.06	—0.02	—0.28	—0.36	....
May	—0.38	—0.43	—0.37	—0.25	+0.54	+0.80	+0.53	+0.15	+0.02	—0.02	—0.20	—0.34	....
June	—0.47	—0.24	—0.25	—0.34	+0.30	+0.87	+0.75	+0.16	+0.02	—0.08	—0.40	—0.37	....
July	—0.56	—0.46	—0.37	—0.15	+0.43	+1.00	+0.83	+0.24	—0.04	—0.14	—0.32	—0.45	....
August	—0.57	—0.47	—0.44	—0.35	+0.47	+1.22	+0.92	+0.13	—0.07	—0.03	—0.32	—0.46	....
September	—0.63	—0.43	—0.54	—0.66	+0.41	+1.05	+0.92	+0.36	+0.15	+0.04	—0.33	—0.39	....
October	—0.23	—0.17	—0.35	—0.45	+0.25	+0.64	+0.67	+0.30	—0.02	—0.18	—0.21	—0.22	....
November	—0.04	—0.15	—0.32	—0.40	+0.09	+0.47	+0.56	+0.22	—0.08	—0.15	—0.14	—0.11	....
December	+0.03	+0.05	—0.20	—0.41	—0.20	+0.30	+0.71	+0.37	—0.18	—0.35	—0.14	0.00	....
Year	—0.32	—0.22	—0.33	—0.38	+0.19	+0.72	+0.71	+0.28	—0.02	—0.13	—0.24	—0.27	....
Summer	—0.51	—0.39	—0.40	—0.36	+0.39	+0.98	+0.78	+0.22	+0.02	—0.04	—0.31	—0.40	....
Winter	—0.12	—0.05	—0.27	—0.41	—0.01	+0.47	+0.65	+0.33	—0.06	—0.22	—0.17	—0.14	....

Annual inequality in the diurnal variation of the dip.

The comparison of the above diurnal variations for summer and winter with that of the whole year is given in the following Table V:

	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. +21.1.
	′	′	′	′	′	′	′	′	′	′	′	′	
Summer	−0.19	−0.17	−0.07	+0.02	+0.20	+0.26	+0.07	−0.06	+0.04	+0.09	−0.07	−0.13	....
Winter	+0.20	+0.17	−0.06	−0.03	−0.20	−0.25	−0.06	+0.05	−0.04	−0.09	+0.07	+0.13	....

These tabular values are exhibited in diagram A. The diagram shows the hours of no semi-annual change as follows: 5½ a. m., 1 p. m., 3 p. m., and 7 p. m. Greatest change at 10 a. m.; secondary at 6 p. m., with a range of 0.′51 and 0.′18, respectively.

The turning epochs are found by the variations at the hour 10 a. m., when the monthly differences from the annual mean are as follows:

January	− 0.′19	July	+ 0.′28
February	− 0.30	August	+ 0.50
March	− 0.24	September	+ 0.33
April	+ 0.19	October	− 0.08
May	+ 0.08	November	− 0.25
June	+ 0.15	December	− 0.42

These values are represented by the formula,

$$\Delta_a = 0.'35 \sin (\theta + 253^\circ\ 38') + 0.'10 \sin (2\theta + 328^\circ\ 39'),$$

the angle θ counting from January 1. This formula gives a change of sign for the middle of April and the middle of October, or about 25 days after the equinoxes.

Analysis of the solar-diurnal variation of the dip.

The solar-diurnal variation has also been expressed by Bessel's periodic function for each month, summer, winter, and year. The angle θ counts from midnight, at the rate of 15° an hour; a positive sign indicates increase of north dip; a negative sign the reverse. The expressions are derived directly from Table IV. Diagram B exhibits the observed and computed diurnal variation for the summer months, and diagram C for the winter months. Diagram D exhibits the diurnal variation of the dip for summer, winter, and the whole year.

The general character of the three curves (diagram D) is the same; the annual curve has its greatest value about 11 a. m., and its least value about 5 a. m., with a range of about 1.′2. In summer the epochs occur a little earlier, with a range of about 1.′5; in winter the epochs are a little later, and the range is contracted to about 1.′0. There is also a secondary maximum between 1 and 2 a. m., with a less regular secondary minimum occurring at some hour in the afternoon, or early in the night. In summer, however, these minima appear interchanged.

The Toronto curves are similar to those shown on diagram D. The shifting of the epochs is the same as at Philadelphia. The morning minimum is less prominent, and the afternoon minimum constitutes the principal minimum during summer, and also, on the average, during the year. The total annual range is almost exactly the same at the two places, and the times of the principal maxima also nearly coincide.

The following table contains the computed times of the principal maximum and of the morning minimum; also the elapsed time, together with the amount and range for each month and season; also the times, and amount, and range of the afternoon or early night minimum, taken from the diagrams:

TABLE VI.

1841 to 1845.	Principal maximum at—	Amount in minutes.	A. M. minimum at—	Amount in minutes.	Elapsed time between maximum and minimum.	A. M. range.	Afternoon minimum about—	Early night minimum about—	Range of afternoon minimum and principal maximum.
	h. m.	′	h. m.	′	h. m.	′	h.	h.	′
January	11 59	+ 0.69	6 39	− 0.32	5 20	1.01	6	—	1.0
February	12 15	+ 0.67	6 04	− 0.48	6 11	1.15	8	—	0.9
March	11 57	+ 0.72	5 54	− 0.43	6 03	1.15	—	11	—
April	11 11	+ 0.92	5 11	− 0.48	6 00	1.40	—	10	—
May	10 24	+ 0.81	4 07	− 0.46	6 17	1.27	—	11	—
June	11 01	+ 0.91	5 16	− 0.36	5 45	1.27	5	10	1.0
July	10 57	+ 1.00	*3 15	− 0.43	7 42	1.43	5	11	1.1
August	10 49	+ 1.21	4 45	− 0.53	6 04	1.74	4	11	1.3
September	10 56	+ 1.10	4 57	− 0.69	5 59	1.79	—	10	—
October	11 25	+ 0.73	5 17	− 0.49	6 08	1.22	—	10	—
November	11 29	+ 0.60	5 28	− 0.40	6 01	1.00	6	—	0.7
December	12 24	+ 0.69	6 45	− 0.41	5 39	1.10	6	—	1.0
Summer	10 55	+ 1.00	4 45	− 0.48	6 10	1.48	....	....	....
Winter	11 55	+ 0.67	6 00	− 0.39	5 55	1.06	....	....	....
Year	11 22	+ 0.81	5 18	− 0.40	6 04	1.21	....	....	....

* About 3¼ a. m.; minimum not distinctly marked.

The diurnal range is greater about the time of the equinoxes than at any other time, and, in general, less in winter and greater in summer. The afternoon minimum disappears about the time of the equinoxes, and is best marked about the solstices. The early night minimum only disappears about the time of the winter solstice.

TABLE VII.—*Principal epochs of normal dip.*

1841 to 1845.	A. M.	P. M.
	h. m.	h.
January	8 38	3¼
February	8 49	5
March	8 35	5
April	7 46	5¾
May	6 52	5½
June	7 11	3¾
July	6 55	3¼
August	7 16	3
September	7 37	6¾
October	8 03	5
November	8 10	3½
December	9 14	3½
Summer	7 22	4
Winter	8 33	3½
Year	7 50	2¾

The morning epoch is computed to the nearest minute or two; the afternoon epoch is taken from the diagrams.

Solar-diurnal variation of the total force.

The combination of the component values of $\frac{\Delta X}{X}$ and $\frac{\Delta Y}{Y}$ to form the corresponding values of the total force is effected by the formula—

$$\frac{\Delta \varphi}{\varphi} = \sin^2 \theta \frac{\Delta Y}{Y} + \cos^2 \theta \frac{\Delta X}{X},$$

the result being expressed in parts of the force. A plus sign indicates an augmentation of the force; a minus sign a diminution.

TABLE VIII.—*Regular solar-diurnal variation of the total force between July, 1841, and July, 1845.*

Values of $\frac{\Delta \phi}{\phi}$ to six places of decimals; the first three are placed outside the table.

0.000.

1841 to 1845.	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. −21.1.
January	— 056	+ 224	+ 055	— 004	— 007	+ 122	+ 115	+ 273	— 064	— 294	— 202	— 144	....
February	— 178	+ 038	— 100	— 115	+ 108	+ 190	+ 193	+ 358	+ 178	— 241	— 319	— 119	....
March	— 152	+ 099	— 019	— 068	+ 082	+ 072	+ 183	+ 280	+ 019	— 169	— 130	— 189	....
April	— 308	— 126	— 081	+ 015	+ 158	+ 188	+ 205	+ 311	+ 236	— 021	— 292	— 286	....
May	— 375	— 305	— 179	+ 073	+ 194	+ 203	+ 294	+ 431	+ 312	+ 017	— 294	— 379	....
June	— 483	— 274	— 175	— 001	+ 169	+ 312	+ 523	+ 447	+ 362	— 058	— 391	— 428	....
July	— 519	— 363	— 206	+ 069	+ 182	+ 323	+ 504	+ 527	+ 387	— 031	— 377	— 496	....
August	— 433	— 343	— 246	— 056	+ 062	+ 289	+ 646	+ 557	+ 345	— 022	— 357	— 444	....
September	— 408	— 263	— 218	— 142	+ 054	+ 226	+ 436	+ 488	+ 343	+ 022	— 240	— 299	....
October	— 077	+ 082	+ 033	— 056	+ 208	+ 138	+ 135	+ 169	— 032	— 180	— 244	— 177	....
November	— 043	— 033	— 114	— 074	+ 075	+ 075	+ 197	+ 196	— 006	— 065	— 099	— 102	....
December	— 059	+ 137	+ 062	— 017	+ 062	+ 112	+ 142	+ 173	— 071	— 254	— 174	— 122	....
Year	— 257	— 094	— 099	— 031	+ 112	+ 187	+ 298	+ 351	+ 167	— 108	— 260	— 265	....
Summer	— 421	— 279	— 184	— 007	+ 137	+ 257	+ 435	+ 460	+ 331	— 016	— 325	— 389	....
Winter	— 094	+ 091	— 014	— 056	+ 088	+ 118	+ 161	+ 241	+ 004	— 200	— 195	— 142	....

Annual inequality in the diurnal variation of the total force.

The comparison of the above diurnal variations for summer and winter, with that of the whole year, is given in the following table:

TABLE IX.

0.000.

	0h.	2.	4.	6.	8.	10.	Noon.	14.	16.	18.	20.	22h.	m. +21.1.
Summer	— 164	— 185	— 085	+ 024	+ 025	+ 070	+ 137	+ 109	+ 164	+ 092	— 065	— 124	....
Winter	+ 163	+ 185	+ 085	— 025	— 024	— 069	— 137	— 110	— 163	— 092	+ 065	+ 123	....

These tabular quantities are exhibited in diagram E, which closely resembles diagram B, Part VIII, of the vertical force.

The hours of no semi-annual change are 6 a. m. and 7 p. m. The greatest changes take place about 2 a. m. and 4 p. m., with a range of .000370 and .000328 parts of the force, respectively.

The turning epochs are found from the variations at the hours 6 a. m. and 7 p. m. The following numbers are the differences from the respective annual means. For 20*h.* the sign has been changed.

Month.	6 a. m.	Mean 18 and 20.	Mean 6 a. m., 7 p. m.	Month.	6 a. m.	Mean 18 and 20.	Mean 6 a. m., 7 p. m.
January	+ 027	— 122	— 048	July	+ 100	+ 097	+ 098
February	— 084	— 037	— 060	August	— 025	+ 091	+ 033
March	— 037	— 095	— 066	September	— 111	+ 055	— 028
April	+ 046	+ 060	+ 053	October	— 025	— 044	— 034
May	+ 104	+ 080	+ 092	November	— 043	— 059	— 051
June	+ 030	+ 090	+ 060	December	+ 014	— 116	— 051

All expressed in units of the sixth place of decimals.

The values in the last column are represented by the formula—

$$\Delta_a = 0.000075 \sin(\theta + 280^\circ) + 0.000025 \sin(2\theta + 131^\circ),$$

θ counting from January 1. The change of sign occurs about April 4 and about September 12. On the average, therefore, the change takes place about three days after the equinoxes.

Analysis of the solar-diurnal variation of the total force.

The solar-diurnal variation of the total force has also been expressed by Bessel's periodic function. θ is counted from midnight, at the rate of 15° an hour; a positive sign indicates increase of total force; a negative sign the reverse. The coefficients are expressed in parts of the force. The formulæ are deduced directly from Table VIII.

Diagram F exhibits the observed and computed diurnal variation for the summer months, and diagram G for the winter months. Diagram H exhibits the diurnal variation of the total force for summer, winter, and the whole year.

The diurnal curve is single-crested in summer, and, on the average, during the year; but in winter it assumed a double-crested form, having a secondary maximum between 2 and 3 a. m., and a secondary minimum about 6 a. m. The principal maximum in summer occurs about 2 p. m., and in winter about one and a half hour earlier. The principal minimum in summer occurs about 10 p. m.; in winter about two hours earlier. The summer range is about 0.0009 and the winter range about 0.0004 parts of the force.

The following table contains the computed times of the principal maximum and minimum, together with the elapsed time, amount, and range of variation in force for each month and season; also the time and amount of range of the early morning secondary wave, as taken from the diagrams:

TABLE X.—*Total force.*

1841 to 1845.	Principal maximum.	Amount, 0.000	Principal minimum.	Amount, 0.000	Elapsed time.	A. m. and p. m. range, 0.00	A. m. secondary maximum.	A. m. secondary minimum.	Secondary range, .000
	h. m.		*h. m.*		*h. m.*		*h.*	*h.*	
January	13 02	+ 225	19 38	— 283	6 36	0508	3	7½	15
February	14 00	+ 320	20 19	— 331	6 19	0651	1	4	07
March	13 07	+ 237	20 45	— 204	7 38	0441	4	7	04
April	14 46	+ 299	21 54	— 342	7 08	0641	—	—	—
May	14 46	+ 422	22 57	— 404	8 11	0826	—	—	—
June	13 41	+ 521	22 32	— 486	8 51	1007	—	—	—
July	14 04	+ 560	23 05	— 522	9 01	1082	—	—	—
August	13 23	+ 618	23 42	— 447	10 19	1065	—	—	—
September	13 54	+ 498	23 33	— 360	9 39	0858	—	—	—
October	11 00	+ 190	20 30	— 266	9 30	0456	2½	5	04
November	12 50	+ 199	20 02	— 118	7 12	0317	0½	4½	04
December	12 33	+ 193	19 29	— 231	6 56	0424	3	7	05
Summer	14 02	+ 485	22 38	— 421	8 36	0906	—	—	—
Winter	12 58	+ 220	20 11	— 229	7 13	0449	2½	6	04
Year	13 36	+ 344	21 28	— 296	7 52	0640	—	—	—

The amount and range are expressed in parts of the force. The time of the principal maximum and minimum is computed to the nearest minute or two. The diurnal range is greatest during summer, and least during winter. The small secondary inflexion obtains only during the winter months. Its range is only about the seventieth part of the larger annual range.

Table XI contains the principal morning and afternoon epoch of the normal value of the total force.

The morning epoch is taken from the diagrams; the afternoon epoch is computed.

TABLE XI.—*Epochs of normal total force.*

1841 to 1845.	A. M.	P. M.
	h.	*h. m.*
January	9	4 02
February	7	5 16
March	8½	4 51
April	5½	6 15
May	5½	6 22
June	6¼	6 07
July	5¾	6 13
August	7¼	6 03
September	8	6 35
October	Not reached.	4 18
November	7¾	4 48
December	Not reached.	3 42
Summer	6.5	6 15
Winter	7.4	4 35
Year	6.6	5 38

Annual inequality of the dip and total force.

The differences of the monthly normals, expressed in parts of the horizontal force, have been taken from Table XII of Part V. The mean of the October and December values, however, has been substituted for the November value, which produced a correction of +0.00004 to each monthly value to balance the annual sum. The approximate values of the annual inequality of the vertical force are extracted from Part VIII, after converting the scale divisions into parts of the vertical force.

Table XII contains the values of the annual inequality for the horizontal and vertical components, and, by combination, those of the dip and total force.

TABLE XII.

	$\frac{\Delta X}{X}$	$\frac{\Delta Y}{Y}$	$\Delta\Theta$	$\frac{\Delta\phi}{\phi}$
January	− 0.00045	− 0.00003	+ 0.4	− 0.00008
February	− 15	− 53	− 0.4	− 50
March	+ 23	00	− 0.2	+ 02
April	− 03	− 03	0.0	− 03
May	+ 39	+ 36	0.0	+ 36
June	+ 06	+ 53	+ 0.5	+ 49
July	+ 43	+ 17	− 0.3	+ 19
August	+ 05	+ 20	+ 0.2	+ 19
September	− 20	− 20	0.0	− 20
October	− 13	− 13	0.0	− 13
November	− 12	− 40	+ 0.3	− 37
December	− 11	− 03	+ 0.1	− 04

* From what has been said of the annual inequality of the horizontal and vertical force, it could not be expected that this inequality should appear in any decided manner in the dip and total force. With reference to the dip, all that can be concluded is that the inequality, probably, does not exceed half a minute. At Toronto, where the dip is greater, it is between 0.'8 and 0.'9; lower in June and July than in January and December; range, 1.'7. With respect to the total force, the inequality seems to be about 0.0003 parts of the force, which gives nearly the same range as that found at Toronto, with this difference, however, that at Philadelphia the force is greater in the summer months and less in the winter months, the reverse of what has been found at the other stations.

The next and last part of the discussion of the Girard College magnetic observations will contain the absolute values of the magnetic declination, dip, and intensity.

APPENDIX No. 18.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART XII.—DISCUSSION OF THE MAGNETIC INCLINATION, AND TABLE OF ABSOLUTE VALUES OF THE DECLINATION, INCLINATION, AND INTENSITY, BETWEEN 1841 AND 1845. BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.

[From the Smithsonian Contributions to Knowledge.]

Results and discussion of the observations for magnetic inclination taken at Girard College, Philadelphia, in 1842, 1843, and 1844.

The dip circle was made by Robinson, of London, in 1836, and is six inches in diameter.* The needles used are No. 1 and No. 2, and the poles were reversed in each set of observations. The ends of the needles are marked A and B. The instrument was mounted upon a marble pier about 20 feet to the southeast of the observatory. The observations for dip were made once each week, and were commenced in January, 1842; they terminated in July, 1844. There are some interruptions, however, in the series of observations, as will be noticed in looking over the results of Table No. 1. This table contains an abstract of the results taken directly from the record. It has also been compared with the synopsis of the resulting dips in volume III of the record. The time is observatory mean time, counted, for convenience, from $0h.$ to $24h.$ Each mean result consists of twenty-four separate measures, with face of instrument west and east, marked side of the needle west and east, and with polarity north and south. Three readings have been taken in each position of face of the needle. With but a few exceptions, needle No. 1 was employed throughout the series. In the exceptional cases, where needle No. 2 or one of the Lloyd needles No. 1 or No. 3 were used, special corrections to refer their indications to the result by needle No. 1 have been deduced and applied.

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* It is the same instrument with which I made the observations at stations in Europe, (Amer. Phil. Trans., vol. VII, part 1, 1840,) and those in the magnetic survey of Pennsylvania in 1840 and 1841, and at other stations further northward and eastward in 1843.

TABLE No. 1.—*Abstract of results of magnetic dip observed at Girard College Observatory between 1842 and 1844.*

Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1. A north.	Dip, needle No. 1. B north.	Dip, needle No. 1. Mean.	Mean monthly dip.
				° ′	° ′	° ′	° ′
1842.							
January	4	10	0	71 56.4	71 55.2	71 55.8	71 57.5
	11	10	0	71 58.6	71 53.6	56.1	
	18	10	0	72 00.9	71 55.0	57.9	
	25	10	0	71 56.3	72 04.4	60.3	
February	1	10	0	72 01.9	71 57.1	59.5	71 58.4
	8	10	0	72 03.6	71 55.1	59.4	
	15	10	0	71 58.0	71 53.2	55.6	
	22	10	0	72 02.0	71 56.7	59.3	
March	1	10	0	72 08.1	71 49.5	58.8	71 59.5
	8	10	0	72 04.6	71 51.0	57.8	
	15	10	0	72 07.5	71 52.7	60.1	
	22	10	0	72 08.2	71 55.7	62.0	
	29	10	0	72 02.6	71 54.9	58.7	
April	5	10	0	71 46.4	71 55.5	51.0	71 59.0
	12	10	30	72 06.2	71 57.0	61.6	
	19	9	35	72 08.5	71 55.3	61.9	
	26	9	58	72 10.5	71 52.4	61.4	
May	3	10	19	72 11.4	71 56.1	63.7	71 61.3
	17	9	29	72 09.4	71 59.4	* 64.4	
	17	10	43	71 54.2	72 02.6	58.4	
						+1.7	
	24	10	0	72 11.6	71 51.3	61.4	
	31	10	1	72 06.7	71 48.9	57.8	
June	7	10	15	72 11.8	71 53.4	62.6	71 60.7
	14	9	46	72 09.1	71 52.9	61.0	
	21	9	56	71 57.1	71 59.1	58.1	
	28	9	24	72 07.8	71 54.3	61.0	
July	13	9	11	72 10.2	71 58.3	64.3	71 57.2
	19	9	52	71 54.2	71 53.1	53.6	
	26	9	34	71 49.2	71 57.9	53.6	
August	3	9	42	73 01.4	72 00.5	61.0	71 60.2
	9	10	1	72 06.3	71 53.5	59.9	
	16	9	57	72 04.2	71 54.8	59.5	
	30	9	40	72 05.0	71 56.2	60.6	
September	6	9	4	72 10.0	71 58.7	64.3	71 61.2
	13	9	55	71 56.7	71 58.8	57.8	
	27	9	43	72 08.6	71 54.6	61.6	
October	4	10	12	72 07.0	71 55.4	61.2	71 60.6
	11	10	8	72 06.4	71 55.6	* 61.0	
	11	11	17	71 51.3	72 03.2	57.2	
						+1.7	
November	1	10	6	72 11.9	72 01.5	66.7	71 64.1
	15	9	48	72 08.3	71 52.3	60.3	
	22	10	13	72 13.3	71 57.1	65.2	
December	27	9	16	72 08.2	71 55.3	61.7	71 61.7
1843.							
April	11	10	53	71 58.0	71 42.5	50.3	71 54.9
	18	13	10	72 08.2	71 48.9	58.5	
	25	10	0	71 59.7	71 52.0	55.8	
May	2	9	40	72 11.7	71 44.7	58.2	71 63.2
	9	9	25	72 11.8	72 08.2	70.0	
	16	10	22	72 00.3	72 14.9	67.6	
	23	9	50	71 59.2	72 12.9	66.1	
	30	9	55	72 05.6	71 42.7	54.1	
June	6	10	22	72 09.5	71 54.5	62.0	71 57.7
	13	10	20	72 10.7	71 57.8	64.2	
	20	10	5	71 56.5	71 45.4	51.0	
	27	9	55	71 58.8	71 48.2	53.5	

Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1. A north.	Dip, needle No. 1. B north.	Dip, needle No. 1. Mean.	Mean monthly dip.
				° ′	° ′	° ′	° ′
1843.							
July	4	10	25	72 01.4	71 56.3	71 58.8	71 57.5
	11	10	35	72 07.9	71 44.3	56.1	
	18	10	5	72 04.9	71 51.5	* 58.2	
	18	11	20	71 58.8	71 55.5	57.2	
						+1.7	
	20	16	37	†71 56.2	‡71 45.3	56.7	
				+1.9	+10.0		
August	22	10	5	§71 53.4	‖72 12.3	64.1	71 60.5
				+4.3	−1.8		
	24	11	17	72 02 0	71 50.7	* 56.3	
	24	12	0	72 01 6	72 00.2	60.9	
						+1.7	
	26	17	46	†71 54.0	‡71 51.2	58.6	
				+1.9	+10.0		
	29	10	25	72 05.1	71.55.5	60.3	
	29	11	55	†71 56.3	‡71.50.3	59.3	
				+1.9	+10.0		
September	5	9	42	72 07.3	71 52.0	59.6	71 60.7
	5	11	12	†71 58.9	‡71 49.3	60.0	
				+1.9	+10.0		
	12	9	56	72 02.7	71 53.7	* 58.2	
	12	11	17	71 54.8	71 57.0	55.9	
						+1.7	
	12	13	5	†71 57.1	‡71 48.4	58.7	
				+1.9	+10.0		
	19	9	40	72 02.9	71 59.6	61.3	
	26	9	52	72 04.1	72 03.1	63.6	
October	3	9	25	71 55.2	71 49.0	52.1	71 54.8
	10	9	32	71 56.9	71 55.2	56.0	
	17	9	42	71 50.8	72 00.7	55.7	
	24	9	40	72 00.1	71 53.4	56.8	
	31	9	32	71 56.3	71 51.0	53.6	
November	7	9	45	72 01.2	71 51.5	56.4	71 56.4
	14	10	17	72 00.7	71 57.5	59.1	
	21	10	10	72 02.1	71 47.7	54.9	
	28	10	25	72 02.5	71 48.1	55.3	
December	5	10	20	72 01.9	71 51.7	56.8	71 57.7
	12	10	42	72 05.7	71 58.3	62.0	
	19	10	12	71 59.0	71 51.8	55.4	
	26	10	40	72 00.5	71 52.6	56.6	
1844.							
January	2	10	20	71 57.6	71 53.8	55.7	71 56.2
	9	9	52	72 04.0	71 54.0	59.0	
	16	10	40	72 01.2	71 52.8	57.0	
	23	10	12	71 57.8	71 50.5	54.1	
	30	10	17	71 58.9	71 51.7	55.3	
February	6	10	25	71 59.3	71 57.9	58.6	71 59.5
	13	10	22	72 01.0	71 59.1	60.0	
	20	10	12	71 59.1	72 01.2	60.1	
	27	10	47	71 59.7	71 58.5	59.1	
March	5	11	10	71 56.6	71 59.1	57.8	71 58.6
	12	9	56	71 56.6	71 58.7	57.7	
	19	10	22	72 01.5	72 02.2	61.9	
	26	9	55	71 58.6	71 55.3	57.0	
April	2	10	57	72 04.1	71 52.7	58.4	71 55.9
	9	10	1	71 55.2	71 54.8	55.0	
	16	10	7	71 59.1	71 55.9	57.5	
	23	10	18	71 55.7	71 49.4	52.6	
	30	9	55	72 00.6	71 51.5	56.1	

* Needle No. 2.
‡ Lloyd needle No. 3, A end north.
‖ Needle No. 2, B end north.
† Lloyd needle No. 1, A end north.
§ Needle No. 1, B end north.

TABLE No. 1.—*Abstract of results of magnetic dip, &c.*—Continued.

Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1.			Mean monthly dip.	Year and month.	Day.	Hour.	Minute.	Dip, needle No. 1.			Mean monthly dip.
				A north.	B north.	Mean.						A north.	B north.	Mean.	
1844.				° ′	° ′	° ′	° ′	1844.				° ′	° ′	° ′	° ′
May	7	9	50	71 57.2	71 54.5	71 55.8		July	4	12	53	71 56.5	71 56.6	71 56.6	
	14	9	49	71 59.0	71 54.4	56.7			16	10	37	72 02.1	72 06.7	64.4	
	21	10	9	71 57.5	71 57.0	57.3	71 57.1		23	10	48	71 56.3	71 57.7	57.0	71 58.9
	28	9	50	71 59.5	71 57.6	58.5			30	10	40	72 00.4	71 54.8	57.6	
June	18	11	47	71 59.5	71 55.1	57.3	71 57.3								

Determination of corrections to results by needle No. 2, by Lloyd needles Nos. 1 and 3, and for want of reversal of polarity for needles Nos. 1 and 2, on August 22, 1843.—Needle No. 1 being that ordinarily used, the exceptional readings with the other three needles have been referred to the indications of needle No. 1.

The index error to needle No. 2 we find by direct comparison with needle No. 1 on the following dates:

May 17, 1842.	Correction, +6.0′		
October 11, 1842.	Correction, +3.8		
July 18, 1843.	Correction, +1.0	Mean, +1.′7.	
August 24, 1843.	Correction, −4.6		
September 12, 1843.	Correction, +2.3		

The correction to the Lloyd needles Nos. 1 and 3, A end north, we obtain also by direct comparison, viz:

August 29, 1843.	Correction to Lloyd No. 1, +4.0′;	to Lloyd No. 3, +10.0′
September 5, 1843.	Correction to Lloyd No. 1, +0.7;	to Lloyd No. 3, +10.3
September 12, 1843	Correction to Lloyd No. 1, +1.1;	to Lloyd No. 3, + 9.8
	Mean correction, +1.9	+10.0

The corrections for polarity to needles 1 and 2 are determined as follows:

	° ′
For needle No. 1.—Mean dip in 1843 from 34 results, A north	71 62 4
Mean dip in 1843 from 34 results, B north	71 53.8
Mean dip	71 58.1

Hence, correction to needle 1, A north, −4.′3, and B north, +4.′3.

For needle No. 2 we have the following differences:

May 17, 1842.	A north—B north, − 8.4′	
October 11, 1842.	A north—B north, −11.9	
July 18, 1843.	A north—B north, + 3.3	Mean, −3.′6.
August 24, 1843.	A north—B north, + 1.4	
September 12, 1843.	A north—B north, − 2.2	

Hence, correction to needle 2, A north, +1.′8; B north, −1.′8.

The above corrections have been applied.

Recapitulation of monthly means of inclination.

Month.	1842.	1843.	1844.
	71° +	71° +	71° +
January	57′.5	....	56′.2
February	58.4	....	59.5
March	59.5	....	58.6
April	59.0	54.′9	55.9
May	61.3	63.2	57.1
June	60.7	57.7	57.3
July	57.2	57.5	58.9
August	60.2	60.5	....
September	61.2	60.7	....
October	60.6	54.8	....
November	64.1	56.4	....
December	61.7	57.7	....
Mean	60.1	58.2	57.6

The preceding results indicate an annual diminution of the dip of 1.′2. To complete the dip for the year 1843, the values for January, February, and March have been interpolated, by taking the means of 1842 and 1843 of these months, respectively. The interpolated dips are 71° 56.′9, 58.′9, and 59.′0. We have the final values:

	°	′
Dip for 1842.5	72	01.1
Dip for 1843.5	71	58.2
Dip for 1844.4	71	57.6

If we divide the monthly means (inclusive of the interpolated dips for January, February, and March, 1843) into two parts, we find the values—

	°	′
From January, 1842, to April, 1843, inclusive	71	59.4
From April, 1843, to July, 1844, inclusive	71	57.9

The corresponding epochs are September 1, 1842, and December 1, 1843, which again gives an annual decrease of 1.′2. It is desirable, however, to extend the investigation of the annual effect of the secular change of the dip beyond the years above stated. In the Coast Survey report for 1856,* Assistant Schott discussed the secular change of the dip at various places, and finds that the middle of the year 1842 (1842.7 ± 0.7 years) was an epoch of minimum dip for places between Cambridge, Massachusetts, Toronto, Canada, and Washington, District of Columbia. The expression for the secular change for Philadelphia (page 241 of the 1856 report) is derived from 19 observations, contracted to 8 normals, between 1834 and 1855.

The dips extracted from a manuscript paper on my magnetic surveys in various parts of the northeastern States during the years 1834–'35, 1840, 1841, and 1843 are as follows:

Observed dip at Philadelphia:

	°	′
July 21, 1840	71	52.6
October 28, 1840	71	53.0
April 26, 1841	72	00.6
July 20, 1841	71	57.0
October 9, 1841	71	58.2
November 1, 1841	71	59.1

* Appendix No. 32, page 235.—Discussion of the secular variation of the magnetic inclination in the Northeastern States.

A collection and combination of all the observed values for dip at Philadelphia (as far as they have come to my notice) are given in the following table:

Date.	Observer.	Dip.	Mean dip.	Mean epoch.
		° ′	° ′	
July, 1834	Professor Bache and Professor Courtenay	71 60.2	72 00.2	1834.5
July, 1838	Professor Bache	71 43.9	Excluded.	
September, 1839	Professor Loomis	71 67.1	72 07.1	1839.7
July, 1840	Professor Bache	71 52.6	71 53.0	1840.7
September, 1840	do	71 53.3		
October, 1840	do	71 53.0		
March, 1841		71 60.7	71 58.4	1841.5
April, 1841	Professor Bache	71 58.2		
Do	do	71 60.6		
Do	do	71 59.0		
June, 1841	Major Graham	71 54.5		
July, 1841	Professor Bache	71 57.0		
October, 1841	do	71 58.2		
November, 1841	do	71 59.1		
November, 1842	Doctor Locke	71 60.1	71 59.7	1842.5
Do	Captain Lefroy	71 59.0		
January to December, 1842	Professor Bache	71 60.1		
April to December, 1843	do	71 58.2	71 58 2	1843.6
April to December, 1844	Major Graham	71 61.8	72 02.0	1844.3
April, 1844	Doctor Locke	71 59.3		
May, 1844		71 69.2		
January to July, 1844	Professor Bache	71 57.6		
May, 1846	Doctor Locke	71 61.0	72 01.0	1846.4
September, 1855	Assistant Schott	71 77.7	72 17.7	1855.7
August, 1862	do	71 65.8	72 05.8	1862.6

The annual irregularity in the dip need not be considered, as the index error of the various needles and the observing errors are much greater than the maximum amount of that irregularity, which, according to the Toronto observations, hardly exceeds $\pm 1'$.

Collecting the mean dips and mean epoch, and adopting the expression—

$$\theta = \theta_1 + x + y(t - t_0) + z(t - t_0)^2,$$

where,

θ = resulting dip at any time between 1830 and 1860;

θ_1 = assumed dip at epoch, x its correction, $\theta_1 = 72^\circ\ 00$;

t_0 = epoch or 1840.0;

t = any other time between the above limits;

we obtain from the following combination of the observations, by the method of least squares, the values x, y, and z:

		Mean dip.	Mean year.
Group I	3 results	72.°00	1838.3
Group II	5 results	72.00	1843.5
Group III	2 results	72.20	1859.2

whence $\theta = +72.^\circ00 - 0.00011(t - 1840) + 0.00060(t - 1840)^2$.

The observed and computed dips compare as follows:

Epoch.	Observed dip.	Computed dip.	Obs'd—Com'd.
1834.5	72°.00	72°.02	− 0°.02
1839.7	72.12	72.00	+ 0.12
1840.7	71.88	72.00	− 0.12
1841.5	71.97	72.00	− 0.03
1842.5	72.00	72.00	0.00
1843.6	71.97	72.01	− 0.04
1844.3	72.03	72.01	+ 0.02
1846.4	72.02	72.03	− 0.01
1855.7	72.29	72.15	+ 0.14
1862.6	72.10	72.31	− 0.21

The probable error of any one representation is ± 4.′8. The minimum dip, according to the above formula, occurred in January, 1840; at Toronto this minimum occurred in 1843.

By means of the formula we find the dip for the middle of each year:

Year.	Computed dip.	Observed dip.	Adopted dip.
1840–5	72°.00	....	72° 59′
1841–5	72.00	....	71 59
1842–5	72.00	72°.00	72 00
1843–5	72.01	71.97	71 58
1844–5	72.01	71.97	71 58
1845–5	72.02	....	72 01

We may now collect in one table the numerical values of the magnetic elements, as found in the preceding discussion. The units for the force are feet and grains; + indicates west declination and north dip.

Girard College, Philadelphia.

Epoch.	ψ	θ	X	Y	ϕ
January, 1841	+ 3° 23′	+ 71° 59′	4.178	12.85	13.51
1842	3 28	71 59	4.175	12.84	13.50
1843	3 32	71 59	4.173	12.83	13.49
1844	3 36	71 58	4.170	12.81	13.47
1845	3 41	72 00	4.168	12.83	13.49
Mean January, 1843	+ 3 32	+ 71 59	4.173	12.83	13.49

The latitude of the observatory is .... 39° 58′.4
And its longitude west of Greenwich 75 10.1
Or .... $5^h\ 00^m\ 40^s.3$

To facilitate the use of the several parts of the discussion of the Girard College magnetic observations a complete index is here given.

APPENDIX No. 19.

RESULTS OF MAGNETIC OBSERVATIONS MADE IN THE UNITED STATES BY PROFESSOR J. N. NICOLLET BETWEEN 1832 AND 1836.—COMMUNICATED BY A. D. BACHE, LL.D., PRESIDENT NATIONAL ACADEMY OF SCIENCES, SUPERINTENDENT UNITED STATES COAST SURVEY.—MAY, 1864.

An examination of an unpublished manuscript of certain magnetic observations, made principally in the interior of the United States by the late Professor J. N. Nicollet, about the epoch 1834, led me to the conclusion that a discussion and publication of the results of these observations might prove advantageous to science. The manuscript is incomplete, as it contains but a small portion of the record, but a summary of most of the crude results, as immediately resulting from the observations, is preserved in Mr. Nicollet's handwriting. Owing to the incompleteness of the record and the imperfection of the instrumental means at that period, the results can claim but a small amount of accuracy. Still, it was thought that their comparatively early date, and the absence of any other and better observations at some of the stations even at the present day, would, nevertheless, attach to them some value, especially in investigations of the secular change of the magnetic elements.

Table of geographical positions of magnetic stations.

Station.	Latitude.	Longitude.	Authority.	Point of reference.
	° ′	° ′		
Baltimore, Md	39 17.8	76 36.6	United States Coast Survey	Washington monument.
St. Louis, Mo	38 37.5	90 15.3	American Almanac, 1861	Chauteau's garden.
Lexington, Ky	38 06	84 18	......do............do	
Smithland, Ky	37 08	88 30	Colton's Atlas	
Nashville, Tenn	36 09.5	86 49.1	American Almanac, 1861	
Knoxville, Tenn	35 59	83 54	......do............do	
Warm Spring, N. C	35 50	82 48	Colton's Atlas	
Ashville, N. C	35 36	82 30	......do	
Athens, Ga	33 57	83 25	......do	
Augusta, Ga	33 28	81 54	American Almanac, 1861	
Charleston, S. C	32 46.7	79 55.7	United States Coast Survey	Circ. church.
Natchitoches, La	31 44	93 05	Colton's Atlas	
Natchez, Miss	31 33.8	91 24.7	American Almanac, 1861	Fort; Chotard's residence.
Mobile, Ala	30 41.4	88 01.5	United States Coast Survey	Episcopal church; Batre's garden.
New Orleans, La	29 57.8	90 02.5	......do............do	Mint.
Tallahassee, Fla	30 28	84 36	American Almanac, 1861	
Tuscaloosa, Ala	33 12	87 42	......do............do	
St. Peter, Minn	44 48	93 10	American Almanac, 1861, and C. A.	Fort Snelling; Major Tagliaferro's.
Cape Henry, Va	36 55.5	76 00.2	United States Coast Survey	Light-house.

1.—*Horizontal force.*

The following table contains the times of 300 vibrations, with five needles, for relative horizontal intensity. At four stations only we have a record of the temperature, which, however, proved insufficient to deduce any corrections for changes of temperature. The observations at each of the four stations are very consistent among themselves. The results by a sixth needle (No. 12) were rejected by Mr. Nicollet, the irregular results justifying their rejection.

General table of times of 300 vibrations of 5 needles for horizontal intensity.

Locality.	Date.	Needles.					Mean.
		No. 1.	No. 2.	No. 11.	No. 13.	No. 14.	
		s.	*s.*	*s.*	*s.*	*s.*	*s.*
Baltimore	July, 1832	1102	1132	1149	1059	966	1081.6
St. Louis	July, 1835	1081	1132	1098	1117	1040	1093.6
Nashville	November, 1833	1016	1061	[1072]	1200	1009	1071.5
Athens	May, 1833	975	1020	952	957	911	963.0
Do	August, 1834	991	1038	994	1007	944	994.8
Do	September, 1834	969	1029	974	994	913	979.8
Augusta	February, 1833	973	1015	950	954	907	959.8
Charleston	January, 1833	965	989	939	947	856	939.2
Natchez	May, 1834	929	970	922	938	884	928.6
Mobile	do	935	979	930	935	877	931.2
Do	May, 1835	947	993	957	976	912	957.0
Natchez	March, 1836	954	1001	972	990	920	967.4
St. Louis	June, 1836	1076	1127	1093	1112	[1027]	1086.9
St. Peter	July, 1836	1239	1295	1263	1286	1190	1254.6

The two values in brackets were interpolated as follows: For needle No. 11 the mean of the four needles Nos. 1, 2, 13, and 14 was taken, and the result by No. 11 compared with it for each station. The mean difference was thus obtained, and applied to the mean of the other needles at Nashville. For needle No. 14 the mean of Nos. 1, 2, 11, and 13 was compared with No. 14, and the correction for St. Louis applied accordingly.

The next table contains the time T of one vibration and the values of $\frac{1}{T^2}$, which are proportional to X, the horizontal force. By means of this column we obtain an approximate value for the loss of magnetism of the needles, which appears to have been considerable. Taking the differences for the two epochs at St. Louis, Athens, Mobile, and Natchez, we find a loss for 61 months of 0.016154, and for one month of 0.000265. The next columns contain the difference, in months, from the adopted epoch, July, 1834, the correction for loss of magnetism, and the corrected values $\frac{1}{T^2}$.

Station.	Date.	T.	$\frac{1}{T^2}$	Differential epoch.	Correction for loss of magnetism.	Corrected $\frac{1}{T^2}$	Mean.
		s.		*m.*			
Baltimore	July, 1832	3.605	0.076945	+ 24	− 6360	0.070585	....
St. Louis	July, 1835	3.645	0.075266	− 12	+ 3180	0.078446	....
Nashville	November, 1833	3.572	0.078375	+ 8	− 2120	0.076255	....
Athens	May, 1833	3.210	0.097051	+ 14	− 3710	0.093341	....
Do	August, 1834	3.316	0.090945	− 1	+ 265	0.091210	....
Do	September, 1834	3.266	0.093748	− 2	+ 530	0.094278	0.092943
Augusta	February, 1833	3.199	0.097719	+ 11	− 2915	0.094804	....
Charleston	January, 1833	3.131	0.102009	+ 12	− 3180	0.098829	....
Natchez	May, 1834	3.095	0.104395	+ 2	− 530	0.103865	....
Mobile	do	3.104	0.103791	+ 2	− 530	0.103261	....
Do	May, 1835	3.190	0.098270	− 10	+ 2650	0.100920	0.102090
Natchez	March, 1836	3.225	0.096148	− 20	+ 5300	0.101448	0.102657
St. Louis	June, 1836	3.623	0.076183	− 23	+ 6095	0.082278	0.080362
St. Peter	July, 1836	4.182	0.057179	− 24	+ 6360	0.063539	....

To introduce the horizontal force in absolute value we have X for Baltimore, St. Louis, and Mobile, as follows:

Baltimore, (Coast Survey report for 1861, Appendix No. 22, page 247:) The mean of the first three values or X = 4.255; the value of X changes but little in seven years.

St. Louis, (reference as above:) The first value or X = 4.705 is adopted; X changes but little in four years.

Mobile, (Coast Survey report for 1858, page 192:) X in 1857=6.143; hence, in 1834, 6.214, assuming an annual diminution of 0.0005 parts of the force.

Introducing these values, we can form three columns of results, the mean of which has been adopted as an approximation to the horizontal force, expressed in grains and feet.

				X.
Baltimore	4.255	4.133	4.296	4.228
St. Louis	4.844	4.705	4.892	4.814
Nashville	4.597	4.465	4.642	4.568
Athens	5.603	5.442	5.657	4.568
Augusta	5.715	5.551	5.771	5.679
Charleston	5.958	5.786	6.015	5.920
Natchez	6.188	6.010	6.249	6.149
Mobile	6.154	5.977	6.214	6.115
St. Peter	3.830	3.720	3.868	3.806

2.—*Inclination.*

The records of the observations are preserved for two stations only, viz: St. Louis and St. Peter. At St. Louis the method by vibrations in the meridian, and at right angles to it, was employed. This method originated with Laplace, was tested by General Sabine in 1821, also by Rumker and Quetelet; but it appears to have been abandoned since, owing to the imperfection of the results when compared with those obtained by means of a dip circle. It should be remarked that the method applies more properly to smal dips. Let m=the time of a vibration of a horizontal needle in the meridian; p=the time of a vibration when perpendicular to the magnetic meridian; then $\sin I=\frac{m^2}{p^2}$; Mr. Nicollet expressing his inclination as measured from the vertical. He also used an inclinatorium, four position results being given for each resulting inclination. At St. Louis, by the first method, the inclination was 18° 41′; by the second method, 19° 04′. At St. Peter the second method alone was used. As to the method used at the stations given in the general table of results there is no information. The dip, however, as given, is largely affected with index error. I have endeavored to determine an approximate value, at least, of this error, as, without this correction, the results would be of no value.

For St. Louis the following observations are on record:

Year.	Observer.	Reference.	Observed.	Computed.	O—C.
1819.4	Long	Account of Major Long's expedition.	70° 30′	70° 36′	— 6′
1839.5	Locke	Am. Phil. Soc., 1846	69 31.4	69 24	+ 7
1841.7	Nicollet	Am. Phil. Soc., 1843	69 27.1	69 16	+ 11
1841.7	Loomis	Am. Phil. Soc., 1843	69 25.5	69 16	+ 9
1856.8	Friesach	Vienna Academy, 1858	68 01	68 22	— 21

which observations can be expressed by $I=69° 23'-3.'6(t-1839.8)$.

Three results by Nicollet for the mean epoch, 1836.0, give 71° 00′; by the formula we find 69° 37′; hence correction, —1° 23′. At Natchitoches Major Graham observed, in 1840, (Sill. Jour. IV, 1847,) 61° 15.′9; and assuming an annual rate of change of —2′, the result referred to the date of Nicollet's observation, 1834.3, would be 61° 27′; by Nicollet, 64° 01′; hence correction, —2° 34′.

At Mobile Mr. Goodfellow, of the United States Coast Survey, found 60° 51′ in 1857, which, when referred to 1834.5, would probably be 61° 36′; Nicollet has 63° 28′; hence correction, —1° 52′. At New Orleans Mr. Dean, of the United States Coast Survey, found 59° 46.′5 in 1858, which, when referred to 1834.3, would probably be 60° 34′; Nicollet has 62° 05′; hence correction, —1° 31′.

The mean of these four corrections, or —1° 50′, has provisionally been applied to the observed dips.

Possibly hereafter, when the secular change of the dip is better understood, a more perfect correction can be made out. The tabular results are only rough approximation. The manuscript record, nevertheless, indicates that the observations were made with great care, subject only to a large index error.

The quadrant of Nicollet's inclinatorium was divided into 90°, as stated by him.

Place.	Date.		Observed dip.	Approx. corrected dip.	
		° ′	° ′	° ′	
St. Louis	July, 1835	19 02	70 58	69 10	Mean for 1836.0.
Smithland	Dec., 1833	19 59	70 01	68 11	
Nashville	Nov., 1833	21 05	68 55	67 05	
Knoxville	Sept., 1833	21 04	68 56	67 06	
Warm Spring	Sept., 1833	20 31	69 29	67 39	
Ashville	Sept., 1833	20 45	69 15	67 25	
Athens	May, 1833	22 17	67 43	65 40	Mean for 1834.3.
Athens	Aug., 1834	22 25	67 35	....	
Athens	Sept., 1834	22 47	67 13	....	
Natchitoches	April, 1834	25 59	64 01	62 11	
Natchez	Mar., 1834	25 59	64 01	62 11	
Mobile	May, 1834	26 21	63 39	61 38	Mean for 1834.9.
New Orleans	April, 1834	27 55	62 05	60 15	
Tallahassee	Jan., 1835	26 47	63 13	61 23	
Tuscaloosa	April, 1835	23 48	66 12	64 22	
Mobile	May, 1835	26 44	63 16	....	
St. Louis	June, 1836	19 09	70 51	....	
St. Louis	Aug., 1835	18 49	71 11	....	
St. Peter	July, 1836	14 10	75 50	74 00	

3.—*Declination.*

The papers contain the declination at one station—Cape Henry, Virginia. The record is very complete, and the results seem to be entitled to full confidence. The locality is an important one geographically, as well as magnetically, for the study of the secular change of the declination the result is of much value.

The following are the individual results:

$$\left.\begin{array}{r} \text{1832, June 9.—0° 52.5' W.} \\ \text{June 10.—0 47.6 W.} \\ \text{June 10.—0 41.3 W.} \\ \text{June 11.—0 42.3 W.} \\ \text{June 11.—0 41.0 W.} \end{array}\right\} \text{Mean, 0° 45' W.}$$

These observations were obtained by means of a Shenck boussole.

For the discussion of the secular change we have at this station the following values:

Year.	Observer.	Reference.	Declination.
			° ′
1732	Hoxton	Hansteen's Erdmagnetismus	4 42 W.
1732	....	Douglass' History	4 40 W.
1775	....	Des Barres's Atlantic Neptune	5 00 W.
1823.5	H. Boyé	State map of Virginia, 1859	1 32 W.
1832.5	J. A. Nicollet	Manuscript	0 45 W.
1856.7	C. A. Schott	United States Coast Survey Report, 1858	1 28 W.

The position of the light-house at Cape Henry is in latitude 36° 55.′5, longitude 76° 00.′2 west of Greenwich.

APPENDIX No. 20.

REPORT OF ASSISTANT GEORGE W. DEAN ON EXPERIMENTS MADE FOR DETERMINING THE "EDUCTION TIME" OF RELAY MAGNETS OR TELEGRAPHIC "REPEATERS." (SKETCH No. 39.)

NEW YORK, *June* 15, 1864.

DEAR SIR: Your instructions, dated November 24, 1862, authorized me to obtain information in regard to the location and working condition of the telegraph lines between Washington city and San Francisco, California, and more particularly the overland Pacific lines; the view being to ascertain the best plan for exchanging time and star signals by telegraph for the establishment of the difference of longitude between those two places. I was further authorized to obtain the requisite instruments and telegraph apparatus, and proceed to the Coast Survey Office at Washington, and there make such experiments with "relay magnets," generally known as "telegraph repeaters," as might be deemed expedient for the successful execution of the proposed telegraphic longitude operations.

In executing that portion of your instructions relating to the location and working condition of the several lines, I obtained much valuable information by correspondence with J. H. Wade, esq., president of the Pacific Telegraph Company; Colonel Anson Stager, general superintendent United States military telegraph lines; General Marshall Lefferts, engineer for the American Telegraph Company, and several other gentlemen, who possess much practical knowledge relating to telegraph matters. These inquiries were further extended by personal inspection of some of the principal telegraph stations at the west, and for this purpose I visited the cities of Cleveland, Cincinnati, St. Louis, and Chicago during the month of May, 1863.

Those facts thus collected which have a direct bearing upon the execution of the proposed longitude operations were presented in a brief report submitted to you in September last. I now have the honor to report the results of my experiments for determining the "*eduction time*" of electro-magnets of various forms of construction. It may be proper to explain more definitely the sense in which I here use the expression "eduction time."

In every chronographic record which may be made through an electro-magnet, a certain interval of time, however small, must elapse between the instant that a signal is made and that of its record upon the fillet or chronographic paper. The Coast Survey telegraphic experiments for differences of longitude have been chiefly made through electro-magnets in a *closed circuit;* consequently the signals have been made by *breaking* the galvanic circuit, at which instant the induced magnetism of the electro-magnet becomes suddenly diminished, until its attractive power is overcome by the tension of the armature spring, thereby transmitting the signal to the chronographic paper. In case the *open circuit* is used, which in a few instances has been adopted, of course the operation becomes reversed; in other words, the "*induction time*" would be the interval between the *closing* of the circuit and the instant that the induced magnetism of the coils became sufficiently strong to overcome the tension of the armature spring.

In conducting telegraphic experiments, overland, for ascertaining differences of longitude, the *closed* circuit appears to have several advantages over the *open* circuit. All the experiments which I am about to describe have been made in the *closed* circuit.

In completing the arrangements for making these interesting and delicate experiments, the idea occurred to me that either the *induction* or *eduction time* could be measured more accurately by means of the chronographic method, with *two break circuits* in the astronomical clock, than by any other. This apparatus was accordingly constructed under my direction by one of the mechanicians at the Coast Survey Office, Mr. Hunt.

A detailed description of the single-break circuit is given in your report for the year 1856, Appendix No. 21. It consists essentially of a delicate platinum tilt-hammer pivoted on one insulated brass plate, while its head rests upon another, the two plates being connected with the opposite poles of the battery. When the pendulum at each oscillation reaches the vertical, a projecting pin in its centre trips the hammer, thus breaking the circuit and causing a record.

To make the double-break, an additional tilt-hammer was added, constructed in an analogous manner, but so adjusted that it was touched by the pin and tripped at the *highest* point of the oscillation of the pendulum.

Sketch No. 39 sufficiently explains these various parts: C is the insulating bar of ivory; f^1 the brass plate upon which is pivoted the tilt-hammer, a; f the brass plate upon which the head of the tilt rests; A, A^1, are binding posts connecting the brass plates in the circuit.

The second break-circuit is attached to the lower part of the insulating bar, C ; g^1 is the brass plate to which the second tilt-hammer, $b\ b^1$, is pivoted, and g is the one upon which its head, b, rests; B and B^1 are the binding posts connecting these plates in the second circuit; h is a screw for adjusting the position of the tilt, $b\ b^1$.

The clock was adjusted to sidereal time, and its daily rate did not exceed a second.

The method pursued in determining the *eduction time* of electro-magnets was as follows:

The difference of time between the two clock-breaks at every alternate second was first ascertained by connecting the two break-circuits, a and b, in the same galvanic circuit, in which also were connected a chronograph and a first-class fillet register.

The signals thus made by the clock, one being at the *centre* of each oscillation, the other at the highest point of every alternate oscillation, were recorded by the chronograph and fillet registers. The record of these clock-signals was continued about one minute, which gave thirty comparisons of the difference of time between the two signals. This difference was found to be between forty-seven and forty-eight hundredths of a second. It is proper here to remark that in recording the clock signals a second of time was represented upon the fillet paper by a line about two inches in length, while upon the chronograph paper it was indicated by a space a little less than half an inch long; hence the greater accuracy in measuring the fractional parts of the second upon the fillet paper induced me to rely chiefly upon that record.

The comparison of the two clock-breaks having been made, a relay-magnet (Sketch No. 66) was connected in the clock-circuit, B, B^1, while the break-circuit apparatus, A, A^1, remained in the direct circuit with the chronograph register. It will be observed that all the clock signals made through the tilt-hammer a are immediately recorded by the chronograph, while those made by the tilt-hammer b are transmitted through the relay-magnet before they can be recorded by the chronograph. A comparison of the signals thus recorded with those previously made when both clock signals were transmitted through the *same circuit* enables us to obtain the *eduction time* of the relay magnet in the clock-circuit, B, B^1.

In practical telegraphing, when a relay-magnet is connected in what is usually designated the *main circuit* for the purpose of transmitting signals to a *second main circuit* by means of a smaller magnet, which is adjusted in a local or short circuit, the two magnets thus connected and *used together* are called a "*repeater*," from the fact that this particular arrangement of the magnets in the main and local circuits causes every signal to be promptly repeated or transmitted from one main circuit to another at those places where, in the earlier days of telegraphing, a person was required to perform this labor. In the sketch, M is the *main* relay-magnet, and L the *local* magnet.

With these two magnets signals can be transmitted only in *one* direction; hence, for the convenience of sending signals in either direction, a relay-magnet is required in *each* of the two main circuits, which in turn must be connected with its smaller magnet in a local circuit. The sketch represents repeaters arranged for transmitting signals in either direction.

The *eduction time* of a single relay-magnet was first determined, then a single repeater was connected in the clock circuit, B, B^1, after which a second repeater was added, then a third, and finally a fourth. Thus we were enabled to determine the *total eduction time* of four repeaters and one relay-magnet, and at the same time to ascertain the *eduction time* of each particular repeater.

The recapitulation of the results thus obtained is presented in the accompanying table, No. 1; each result is the mean of ten comparisons as recorded upon the fillet paper.

From a casual inspection of these results it will be observed that the retardation or loss of time in the transmission of signals through a telegraph repeater will vary according to the construction and adjustment of each particular instrument. In the repeaters designated as No. 1 and No. 2 in Table No. 1, each main relay was three inches in length, and upon each spool (two of which form the main helix) were twenty-three coils of No. 30 silk insulated copper wire, the entire length of which was about 2,200 feet. The local helices were one and a half inch in length, and one and a fourth in diameter, and each spool contained sixteen coils of No. 22 silk insulated copper wire. The length of the wire upon each local helix was estimated to be between seven and eight hundred feet.

In the repeaters designated No. 3 and No. 4 in Table No. 1, the main relay was four and a half inches in length, and each spool of the main helix contained thirty coils of No. 35 silk insulated copper wire, the length of which was estimated to be 3,600 feet.

The local helices were one and a half inch in length and one inch in diameter. There were fourteen layers of No. 24 silk insulated copper wire upon each spool, and the length of wire in each helix was estimated to be about eight hundred feet.

The diameters of the wires upon the several helices were carefully measured and found to be as follows:

Wire No. 22 was 0.031 of an inch in diameter.

Wire No. 24 was 0.026 of an inch in diameter.

Wire No. 30 was 0.017 of an inch in diameter.

Wire No. 35 was 0.015 of an inch in diameter.

On referring to Table No. 1 it will be noticed that the average *eduction time* of repeaters No. 1 and No. 2, with a maximum tension of the armature spring, was a little more than one-hundredth of a second of time, and with a minimum tension it was four-hundredths of a second; while repeaters No. 3 and No. 4, with a maximum tension, indicated an average *eduction time* of six-hundredths, and with a minimum tension of twelve-hundredths of a second.

The resistance in the helices of repeaters No. 3 and No. 4 was found to be considerably greater than in those of No. 1 and No. 2. This result was expected from the difference in the size and length of wire in the respective coils, though the large difference of the *eduction time* in the several instruments could only in part be attributed to that cause. The experiments which were made with a *maximum* tension of the armature spring clearly indicated that this difference of the *eduction time* was chiefly due to the difference in the construction of the helix cores or soft iron bars.

I think these experiments conclusively demonstrate the fact which Professor Henry many years ago discovered, viz: that the greater the length of the helix core the longer will be the *induction* or *eduction* time of the electro-magnet, other conditions being the same.

Of this discovery by Professor Henry I had no knowledge whatever until I had submitted the results of a series of experiments to him for the purpose of obtaining his views as to the best method for conducting further researches, and I would here express my sincere thanks to him for the very friendly interest which on all occasions he exhibited in these experiments, and for the many suggestions which I received from him.

Professor Henry proposed having the helix cores composed of small well-annealed insulated iron wire, by which the *induction* or *eduction* time would be diminished. The experiments which I had already completed showed that the cores should have a maximum length consistent with the magnetic power required from each relay coil. I accordingly prepared drawings for the construction of a helix which should be provided with several movable cores made of small iron wire insulated with silk. The instrument was manufactured with great care by Mr. E. M. Pierson, telegraph instrument maker, at Cleveland, Ohio, now of Newark, New Jersey.

To Mr. George B. Hicks, of Cleveland, inventor of the "*Hicks's telegraph repeater*," I was indebted for valuable aid in superintending the construction of this instrument.

For greater convenience in making these experiments the instrument was provided with two movable main helices, each two and three-fourths inches in length and one and a half inch in diameter. The helix, which I here designate as No. 1, consisted of forty coils of No. 30 silk insulated copper wire, divided into three series or sections. The first series was of twelve coils, around a thin paper tube, sufficiently large to admit the different iron cores without difficulty. Its length upon each spool was 300 feet. The second series was of twelve coils, immediately around the first, the length being 450 feet. The third was of sixteen coils, around the second, the length 675 feet, thus making the entire length of wire upon each spool 1,425 feet, or 2,850 feet on the two.

The object of dividing each coil into series was to determine the minimum length of wire required upon the helix to produce the necessary magnetic power in the electro-magnet. This was satisfactorily done by first using series No. 1, then series one and two, and finally the three series together.

The length and diameter of the spools of helix No. 2 were the same as those of No. 1.

The first series consisted of fourteen coils of No. 35 silk insulated copper wire around a thin paper tube similar to that used in helix No. 1. The length of wire, in this series, upon each spool was 450 feet. The second series was of fourteen coils, immediately upon the first, the length of which was 600 feet. The third series consisted of eighteen coils, around the second, the length being 1,110 feet, thus making the entire length of wire upon each spool 2,160 feet, or 4,320 feet on the two.

The experiments with this helix were in all respects similar to those made with helix No. 1, and from the results obtained (see Tables Nos. 2 and 3) it appeared that the magnetic power of the electro-magnet, having twenty-four coils of No. 30 copper wire upon its helix, was about the same as when forty coils were used, thus showing that with the same battery force there was no advantage gained by increasing the number of coils from twenty-four to forty. And since these experiments were made under conditions similar to those which are frequently encountered in practical telegraphing through circuits of two or three hundred miles in length, (at least so far as the same resistance in the conducting wires could make the conditions similar,) I infer that no practical advantage can be obtained by increasing the number of coils upon the telegraph relay-magnet above twenty-five or thirty, unless we increase in a corresponding ratio the size of the iron wire now in general use upon most of the telegraph lines in the United States.

I shall again have occasion to refer more particularly to this subject before closing this report.

With helix No. 2 (see Table No. 3) the power of the electro-magnet was found to be *considerably less* when forty-six coils of No. 35 copper wire were upon the helix than when only twenty-eight were used, the battery being the same in both cases.

From a further comparison of the results in these tables it will be observed that the magnetic power of helix No. 1 was much greater than that of No. 2, while a much larger battery was required to overcome the resistance through the No. 35 copper wire with which the latter was constructed, thus confirming the opinion which I have already expressed in regard to the importance of increasing the size of the wire now in general use for telegraph purposes.

The iron cores were constructed in the following manner:

Core No. 1 consisted of two solid soft iron bars, each three inches in length and half an inch in diameter.

Core No. 2 was of the same length and diameter as No. 1, but constructed of well-annealed and insulated iron wire bars, each one-tenth of an inch in diameter.

Core No. 3, of similar dimensions as No. 1 and No. 2, was constructed of well-annealed iron wire six-hundredths of an inch in diameter, and insulated with silk.

Core No. 4 was in all respects similar to No. 3, with the single exception that the iron wire used was but three-hundredths of an inch in diameter.

My first object was to ascertain the relative magnetic power which could be obtained from each of these cores, which I accomplished in the following manner:

The helix constructed of the No. 30 wire was adjusted in a vertical position, so as to allow the several iron cores to be placed consecutively within it while connected in the galvanic circuit. Immediately in contact with the lower surface of the core was placed a soft iron plate similar to that generally used upon the armature of a relay-magnet; this plate was well insulated with silk, and from its centre was suspended a small cup into which mustard-seed shot were slowly dropped until the weight became just sufficient to overcome the attractive force of the magnet, and thus allow the plate to fall from the surface of the core. The exact weight sustained by each core at each consecutive trial was ascertained with a delicate balance which was obtained at the Coast Survey office for this purpose.

Table No. 2 contains a recapitulation of the weights sustained by each core when used in helix No. 1, and Table No. 3 those sustained by the same cores when used in helix No. 2.

From a comparison of these results it will be noticed that the magnetic power of the electro-magnet rapidly diminishes as we diminish the *diameter* of the wire with which the magnet cores may be constructed. In practical telegraph operations we should expect to encounter many difficulties in attempting to exchange signals upon lines from 200 to 500 miles in length with electro-magnets having so little magnetic power as that which was obtained from cores No. 3 and No. 4 under the most favorable conditions. I have no reason to doubt, however, that core No. 2, adjusted in helix No. 1, would perform very satisfactorily in a well-insulated circuit of 200 or 300 miles under favorable conditions of the atmosphere, but during sultry, foggy, or rainy weather, core No. 1 would undoubtedly be found much superior to No. 2.

Tables No. 4, No. 5, and No. 6, contain a recapitulation of the results of the relative *eduction time* of the several cores under similar conditions.

It will be noticed that the *eduction time* of cores No. 2, No. 3, and No. 4, was, upon the average, *less than one-hundredth of a second of time*, while in core No. 1 it varied from one to four hundredths of a second, depending upon the adjustment of the armature spring. The reason for this large difference between core No. 1 and the others was chiefly due to the difference of the magnetic power of the several cores as exhibited in Tables No. 2 and No. 3. The comparatively small variation of the *eduction time* in cores No. 2, No. 3, and No. 4, when the armature spring was adjusted first at a maximum and then at a minimum tension, must, I think, be attributed to the same cause, thereby permitting but very slight change in this adjustment of the instrument.

After the foregoing experiments had been completed, and the results submitted to Professor Henry for his inspection, he suggested that if a narrow groove were cut lengthwise and to the centre of each bar of core No. 1 perhaps the *eduction time* would thereby be somewhat diminished. I accordingly carried the suggestion into execution, and the results herewith presented in table No. 7 prove his theoretical deductions to have been well founded.

So far as I am informed on this subject, the first experiments undertaken for the purpose of measuring the absolute *induction* or *eduction time* of an electro-magnet by means of a well-regulated clock were made during the winter of 1858 by Assistant J. E. Hilgard, aided by Assistant Edward Goodfellow.

Some two years ago Mr. Hilgard very kindly permitted me to look over his results, and I have no doubt that a comparison between them and those of a similar class herewith presented would show a very close agreement, although the method adopted by Mr. Hilgard was somewhat different from that pursued by myself.

Since these experiments were undertaken for the specific purpose of determining, so far as practicable, the best mode of constructing electro-magnets intended to be used as relays for transmitting with the least loss of time signals through long telegraph circuits, I respectfully beg leave to offer a few suggestions in regard to the construction of telegraph instruments, and the size and quality of iron wire which, in my judgment, is most suitable for telegraph purposes; a subject which has at different times engaged my attention while conducting for several years past the telegraph longitude operations of the Coast Survey under your directions.

In the construction of telegraph instruments generally, and more particularly of electro-magnets, no definite system based upon accurate experiments appears to have been adopted in the United States having in view the length, size, and quality of the wire circuits in which such instruments were designed to be used; consequently we find as many electro-magnets of different forms of construction (of both good and bad quality) as there are persons engaged in manufacturing them. So far as I have been able to learn, each instrument-maker has established certain rules of his own for determining the dimensions and form of each particular piece of his instrument; hence, one will construct his relay-magnets with cores *three* inches in length and *half* an inch in diameter, with twenty-five or thirty coils of No. 35 copper wire upon the helix. A second makes his cores *four* inches long, only *three-eighths* of an inch in diameter, and with twenty-five coils of No. 30 copper wire upon the helix, while a third constructs them *four and a half* inches in length and *half* an inch in diameter, with thirty coils of No. 35 copper wire.

These relay-magnets, so entirely different in their construction, are frequently used indiscriminately in circuits varying from one hundred to five hundred miles, the result of which is that great difficulty is often experienced in exchanging signals between distant stations.

It seems to me plain that an electro-magnet having its cores *three and a half* inches in length and *five-eighths* of an inch in diameter, with *thirty* coils of *No.* 30 copper wire upon the helix, will perform more satisfactorily in a circuit four or five hundred miles in length than one with cores *three* inches in length and but *three-eighths* of an inch in diameter, and with only *twenty* coils of *No.* 30, or perhaps *No.* 35, copper wire upon the helix.

It is well known that as the length of the circuit is increased the resistance against the battery current is also greatly increased; hence, to obtain the requisite magnetic power in an electro-magnet which is to be used in a circuit of five hundred miles, we should determine by a complete series of experiments what dimensions should be given to the iron cores, and what number of coils and what size of copper wire ought to be used upon the helix, to produce a maximum power with a minimum current, in connexion with the least *induction* and *eduction time* in the electro-magnets.

The results of the recent experiments have led me to the conclusion that a relay instrument having its iron cores three inches in length and five-eighths of an inch in diameter, with thirty coils of No. 30 copper wire upon its helix, will approximately fulfil these conditions, and with your permission I am now having constructed for the Coast Survey four such instruments, which are to be used in making future determinations of differences of longitude with the electro-magnetic telegraph. It would be expecting too much to suppose that these instruments will at once fully meet all the requirements demanded for the successful execution of the proposed important but difficult longitude operations, and I have no doubt that further experiments will lead to additional modifications and improvements in electro-magnets.

In the United States much study has already been given to the subject of insulation of telegraph lines, while the equally important matter of improving the quality and increasing the size of the iron wire in general use for telegraph purposes has, with a few exceptions, been almost entirely overlooked.

Most of our telegraph lines were originally constructed with wire known commercially as No. 10, which is 0.14 of an inch in diameter, and in some instances No. 11 and No. 12 were used, which are respectively 0.13 and 0.12 of an inch in diameter.

It did not, however, require many years' experience to show that those lines which were constructed of the largest wire possessed several advantages over those in which No. 11 and No. 12 wire were used, and the result has been that upon the principal lines No. 8 and No. 9, each respectively 0.16 and 0.15 of an inch in diameter, have been substituted for No. 10 and No. 11.

Further than this the improvement of the telegraph lines appears to have made but little progress, and I think that I am safe in estimating that at least seven-eighths of our telegraph lines are constructed with No. 8 and No. 9 wire. The exceptional cases are those where a few lines have been constructed with No. 6 iron wire, which is 0.22 of an inch in diameter, through which signals may be exchanged with greater facility than could possibly be done over lines located upon the same routes but constructed of smaller wire.

It is quite evident that this should be the case, because the resistance in the larger wire is much less than in the smaller, and where it has been found otherwise in practice it must have resulted from a less perfect insulation, or, what is still more probable, from the use of an *inferior quality of wire*. Of course the quality of the iron used in manufacturing the larger wire should be equally good with that used for the smaller, and certainly not less attention should be given to the annealing process, for unless we attend to both these points we shall make very little improvement by increasing the size of the wire.

After much careful reflection on the subject I have been led to the conclusion that if all the principal telegraph lines in the United States could be partially reconstructed by substituting No. 6, or, better still, No. 5 iron wire of the best quality, it would, in the end, prove highly advantageous to the several companies. This opinion is based upon the following reasons:

In those sections where dense fogs prevail for weeks in succession, as near the sea-coast of Maine and the British provinces, California and Oregon upon the Pacific coast, and also where it becomes necessary to construct lines through swamps or over low, wet prairies, which are frequently encountered in the southern and western States, the lines will, during such times, be enveloped with moisture, thereby greatly impairing the insulation, and thus reducing the working condition to a minimum standard. The usual remedy under such circumstances is an increase of battery power; but when wire no larger than No. 8 or No. 9 is used this is not always successful, from the want of capacity of the wire. On the other hand, if No. 5 or No. 6 iron wire of the best quality were used, instead of No. 8 or No. 9, the difficulties to which I have alluded could be successfully overcome in foggy or stormy weather by increasing the batteries, and, under the more favorable conditions, *less* battery would be required for operating the line.

Upon an average the battery power used in operating the various telegraph lines in the United States is equivalent to one Grove cell for every five miles of wire in the circuit, whereas by increasing the size of the wire from No. 8 to No. 5 or No. 6 I am quite confident that the amount of battery absolutely required for all practical purposes could be reduced twenty per cent., perhaps more, an item of economy in the operating expenses which would very soon cancel the additional expenditure required for the improved construction.

In regard to the advantages or disadvantages of using galvanized iron wire, my opinion is that when annealed iron wire of good quality is properly galvanized it will be both better and more economical for telegraph purposes. In exceptional cases, where it may be found otherwise, an examination will undoubtedly prove that the wire had been manufactured from an inferior quality of iron, or, perhaps, damaged by fire or water to such a degree as to have rendered it unsalable until its imperfections were covered by being galvanized.

Very respectfully submitted by

GEORGE W. DEAN,
Assistant U. S. Coast Survey.

Prof. A. D. BACHE,
Supt. U. S. Coast Survey.

TABLE No. 1.—*Eduction time in transmitting signals through telegraph "repeaters."*

Date.	Series.	No. of cells in battery.	The tension on the armature spring at a maximum and minimum.									
			Relay-magnet.		Repeater No. 1.		Repeater No. 2.		Repeater No. 3.		Repeater No. 4.	
			Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.
March 14, 1863......	1	3	.000	....	.020	....	.010	....	.050	....	.060	....
	2	3	.010	....	.020	....	.020	....	.040	....	.100	....
	3	1	....	.010	....	.020	....	.020	....	.140	....	.180
	4	1	....	.026	....	.023	....	.028	....	.160	....	.113
March 23, 1863......	5	1	....	.008	....	.020	....	.029	....	.100	....	.187
	6	1	....	.012	....	.020	....	.029	....	.155	....	.125
	7	1	....	.010	....	.033	....	.025	....	.073	....	.208
	8	1	....	.011	....	.028	....	.040	....	.114	....	.166
	9	1	....	.016	....	.031	....	.031	....	.096	....	.181
	10	1	....	.020	....	.023	....	.036	....	.167	....	.113
	11	1	....	.014	....	.027	....	.029	....	.091	....	.196
				.014	....	.025	....	.030	....	.122	....	.163
March 24, 1863......	12	3	....	.024	....	.074	....	.089	....	.102	....	.090
	13	3	....	.015	....	.049	....	.050	....	.054	....	.117
	14	3	....	.013	....	.075	....	.047	....	.070	....	.047
	15	3	....	.011	....	.097	....	.022	....	.072	....	.042
	16	3	....	.014	....	.052	....	.025	....	.082	....	.152
	17	3	....	.020	....	.044	....	.032	....	.089	....	.153
	18	....	.015	....	.010	....	.024	....	.034	....	.095	....
	19	....	.024	....	.017	....	.015	....	.045	....	.086	....
			.013	.018	.013	.065	.016	.044	.042	.078	.085	.100

NOTE.—When the tension of the armature spring was at a minimum, the circuit remained open about one-tenth of a second when each signal was made; and with a maximum tension of the spring, it continued open between three and four-tenths of a second.

TABLE No. 2.—*Experiments for testing electro-magnets of different constructions.*

Date.	Coils of wire on helix.	Length of No. 30 wire on helix.	No. of cells in battery.	Galvanometer reads—		Weight in grains sustained by each core.			
				Without helix in circuit.	With helix in circuit.	No. 1.	No. 2.	No. 3.	No. 4.
1864.		*Feet.*		°	°	*Grs.*	*Grs.*	*Grs.*	*Grs.*
January 25....................	24	1500	1	18	3.5	6032	....	....	....
	24	1500	1	18	3.5	6131	2872	1831	703
	24	1500	1	18	3.5	6215	2759	1876	819
						6126	2815	1853	806
January 25....................	40	2850	1	....	2.0	5626	....	1309	486
	40	2850	1	....	2.0	5700	....	1326	516
						5663	....	1323	501
January 29....................	40	2850	2	23	2.5	7627	2100	2021	991
		2850	2	23	2.5	7485	2006	1980	970
						7556	2053	2000	980
January 29....................	24	1500	2	....	4.5	7626	2983	3198	1600
		1500	2	....	4.5	7500	2950	3110	1646
						7563	2976	3154	1623
January 29....................	40	2850	2	....	2.5	7500	....	....	....
		2850	2	....	2.5	7625	....	....	....
						7562	....	....	....

NOTE.—The copper wire on the helix was No. 30, or 0.017 of an inch in diameter.

TABLE No. 3.—*Experiments for testing electro-magnets of different construction*—Continued.

Date.	Coils of wire on helix.	Length of No. 35 wire on helix.	No. of cells in battery.	Galvanometer reads— Without helix in circuit.	Galvanometer reads— With helix in circuit.	Weight in grains sustained by each core. No. 1.	No. 2.	No. 3.	No. 4.
1864.		*Feet.*		°	°	*Grs.*	*Grs.*	*Grs.*	*Grs.*
January 30	28	2100	5	32	1.5	1716	550	....	360
	28	2100	5	32	1.5	1829	490	....	356
						1772	520	....	358
January 30	46	4320	5	....	1.0	1565	Less than 300 grs.	Less than 300 grs.	Less than 300 grs.
	46	4320	5	....	1.0	1700	....	....	303
						1632	....	....	....
January 30	28	2100	5	....	2.0	2209	681	356	503
	28	2100	5	....	2.0	2245	610	340	486
						2227	645	348	494

NOTE.—The copper wire on the helix was No. 35, or 0.013 of an inch in diameter.

TABLE No. 4.—*Experiments for determining the eduction time of electro-magnets of different construction.*

Date.	Coils of wire on helix.	Length of wire on helix.	No. of cells in battery.	The tension on the armature spring at a maximum and minimum. No. 1. Maximum.	No. 1. Minimum.	No. 2. Maximum.	No. 2. Minimum.	No. 3. Maximum.	No. 3. Minimum.	No. 4. Maximum.	No. 4. Minimum.
1864.				*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*
February 5	24	1500 (No. 30.)	2	.011	.028	.010	.021	.011	.013	.009	.013
	24	1500	2	.005	.037	.004	.010	.006	.013	.004	.012
February 6	24	1500	2	.007	.040	.008	.017	.009	.021	.009	.012
	24	1500	2	.009	.044	.009	.013	.007	.011	.008	.010
				.008	.037	.008	.015	.008	.014	.007	.012
February 8	46	4320 (No. 35.)	3	.003	.034	.001	.012	.002	.005	.005	.002
	46	4320	3	.006	.038	.002	.005	.000	.010	.008	.002
	46	4320	3	.003	.040	.002	.005	.000	.010	.002	.006
	46	4320	3	.003	.043	.002	.008	.004	.006	.003	.007
				.004	.039	.001	.007	.002	.008	.004	.005

TABLE No. 5.

NOTE.—The following experiments were made with a battery of twenty cells, in a circuit of about two miles in length, composed of No. 30 and No. 35 copper wire. The *resistance* was made equal to that usually found upon telegraph lines 200 or 300 miles in length by interposing water in the circuit.

Date.	Coils of wire on helix.	Length of No. 30 wire on helix.	Number of cells in battery.	Galvanometer reads—With 150 feet wire in circuit.	Galvanometer reads—With helix and water interposed in circuit.	The tension of the armature spring at a maximum and minimum. No. 1. Maximum.	No. 1. Minimum.	No. 2. Maximum.	No. 2. Minimum.	No. 3. Maximum.	No. 3. Minimum.	No. 4. Maximum.	No. 4. Minimum.
1864.		*Feet.*		°	°	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*
February 26	24	1,500	20	71	2.0	.003	.032	.003	.009	.010	.011	.003	.009
						.002	.017	.002	.010	.007	.012	.002	.007
						.003	.025	.003	.010	.008	.012	.003	.008
March 5	24	1,500	20	31	1.5	.006	.020	.004	.013	.002	.005	.001	.004
						.003	.021	.004	.015	.003	.008	.001	.009
						.004	.020	.004	.014	.003	.007	.001	.006

TABLE No. 6.

NOTE.—The following experiments were made with the same battery (20 cells) and under similar conditions as those given in the preceding table with the single exception that a different helix was used.

Date.	Coils of wire on helix.	Length of No. 35 wire on helix.	Number of cells in battery.	Galvanometer reads—With 150 feet of wire in circuit.	Galvanometer reads—With helix and water interposed in circuit.	The tension of the armature spring at a maximum and minimum. No. 1. Maximum.	No. 1. Minimum.	No. 2. Maximum.	No. 2. Minimum.	No. 3. Maximum.	No. 3. Minimum.	No. 4. Maximum.	No. 4. Minimum.
1864.		*Feet.*		°	°	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*	*Sec.*
February 27	46	4,320	20	75	1.5	.003	.036	.000	.004	.004	.014	.000	.003
	46	4,320	20	75	1.5	.001	.037	.003	.009	.005	.014	.002	.009
						.002	.036	.002	.007	.004	.014	.001	.006
March 5	46	4,320	20	31	1.5	.005	.033	.004	.010	.003	.009	.003	.007
	46	4,320	20	31	1.5	.006	.034	.008	.011	.005	.010	.004	.008
						.005	.033	.006	.010	.004	.009	.004	.008

TABLE No. 7.

NOTE.—The following experiments were made with core No. 1 after a narrow groove had been cut lengthwise and to the centre of each bar.

Date.	Coils of wire in helix.	Length of No. 35 wire in helix.	Number of cells in battery.	Galvanometer reads— With 150 feet of wire in circuit.	Galvanometer reads— With helix and water interposed in circuit.	The tension on the armature spring at a maximum and minimum. No. 1. Maximum.	No. 1. Minimum.
1864.		*Feet.*		°	°	*Sec.*	*Sec.*
March 1	46	4,320	20	46	1.5	.003	.030
	46	4,320	20	46	1.5	.002	.038
						.003	.034
March 1	28	2,100	20	46	1.5	.004	.027
	28	2,100	20	46	1.5	.004	.033
						.004	.030
March 1	40	2,850	20	46	1.5	.003	.027
	40	2,850	20	46	1.5	.004	.038
						.004	.032
March 1	24	1,500	20	46	1.5	.002	.040
	24	1,500	20	46	1.5	.002	.035
						.002	.037

APPENDIX No. 21.

COMMUNICATION ON THE TRAJECTORY OF RICOCHET SHOT FROM A 15-INCH RODMAN GUN. BY CHARLES A. SCHOTT, ASSISTANT U. S. COAST SURVEY.

COAST SURVEY OFFICE, *July* 19, 1864.

On the 1st and 2d of July, 1864, some shells were thrown experimentally along the channel of the Potomac from two 15-inch guns, mounted at Battery Rodgers and Fort Foote, in order to ascertain their ranges and other circumstances at various elevations. These experiments were made under the immediate direction of General Howe, assisted by Major Hamlin. The operations for the determination of the distances were attended to by myself.

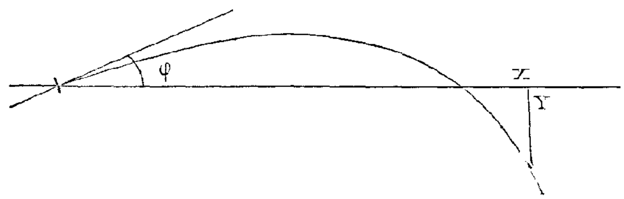
At each place a base line was measured with a steel band, (corrected for temperature,) one end of which was the point of observation for the flight of the shell; the distance of this point from the gun became known by the measure of the angles of the triangle. The distances to some other range objects from the gun were also determined. The angle at the gun between the line of fire (a fixed direction) and the point of observation was measured, as well as the various angles at the latter point, between the gun and the successive impacts of the shot. The ranges, in which these impacts were seen by the observers, clustered for this purpose closely around the central stake, were marked out by stakes in the order in which they occurred, the observers having previously been numbered for this purpose. The angles were measured afterwards with a theodolite. The ranges of the first impact, and of several following ones, as well as the total range, were then computed. Tables were also computed for directions, to be marked by stakes intersecting given constant distances on the line of fire, for the use of future experiments. The results were also graphically laid down.

Thinking that a further development of Poisson's formula to meet the case of a ricochet shot might be of interest and use for the construction of practical tables of ranges, the same is herewith appended, together with an illustration.

For elevations less than 10°, which includes the above experiments, as the ball will not ricochet even with 5° elevation at certain heights above the tide-water, Poisson gives the expression:

$$y = x tg\varphi - \frac{gx^2}{2V^2 \cos^2 \varphi}\left(\tfrac{2}{3}kx + 1\right),$$

where,



y = vertical ordinate of any point in the trajectory.
x = its horizontal ordinate, the origin being at the mouth of the gun.
φ = elevation of gun; for small angle $\cos^2 \varphi$ differs but little from 1.
g = force of gravity = 10.733 yards.
V = velocity of projectile when leaving the gun $= \sqrt{2gh}$.
q = experimental coefficient, generally assumed = 0.225.
δ = density of air.
δ' = density of projectile.
r = radius of projectile.

and $k = \frac{q\delta}{r\delta'}$.

The resistance of the air is assumed proportional to the square of the velocity. If either the initial velocity is determined directly and independently, or the time of flight is experimentally ascertained, the coefficient, k, becomes known. We have,

$$\tfrac{2}{3}k = \frac{2V^2(x tg\varphi - y)}{gx^3} - \frac{1}{x}.$$

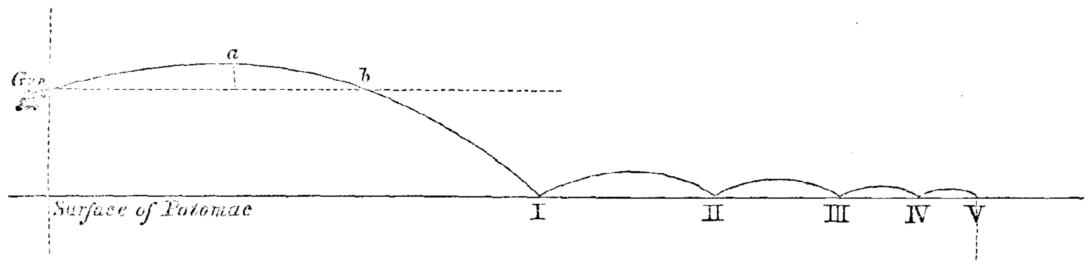
$$V = \sqrt{\frac{gx^2(\frac{1}{3}kx + \frac{1}{2})}{x tg\varphi - y}}.$$

$$t = \frac{e^{kx} - 1}{k\sqrt{2gh}\cos\varphi}, \text{ or, near enough, } t = \frac{e^{kx} - 1}{kV}.$$

$v = Ve^{-kx}$ the velocity at any other point.
$e = 2.71828$, the base of Naperian log's.

The above-mentioned experiments were not made with a view of determining k; we have, therefore, given, φ, x, y, or the height of the gun above the Potomac, viz: $y = -11.7$ yards for the battery, and $y = -30.0$ yards for the fort, and with $q = 0.225$, $r = 0.18$, (allowing for windage,) $\delta = \frac{1}{800}$, (allowing for temperature,) and $\delta' = 7$, k becomes 0.000225 very nearly; φ being also known, (it was varied from 0° to 3°,) the initial velocity, V, from four experiments at the battery, was found = 387 yards, and from three experiments at the fort = 393 yards; the average, or 390 yards, for a ball of about 300 pounds and a charge of 40 pounds of powder, is a tolerable approximation to the value found by Captain Rodman. The assumed value of k appears somewhat too great. We take, as a special case, the investigation of the trajectory of the second shot fired at Fort Foote, the elevation being 2°. The ranges were measured as follows:

From gun to first impact, 1,334 yards; bound, 544 yards.
From gun to second impact, 1,878 yards; bound, 327 yards.
From gun to third impact, 2,205 yards; bound, 195 yards.
From gun to fourth impact, 2,400 yards; bound, 149 yards.
From gun to last impact, 2,549 yards.



Substituting $y = -30.0$, $x = 1334$, $\varphi = 2°$, and $k = 0.000225$, in the expression for V, we find the initial velocity = 387 yards; and from the expression for t, the time of flight = 4.302, also the velocity just before the first impact, $v = 286$ yards. To find the horizontal range, put $y = 0$, hence $tg\varphi = \frac{gx}{2V^2} + \frac{kgx^2}{3V^2}$; or,

$$x = \frac{-\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{4tg\varphi kV^2}{3g}}}{\frac{2}{3}k} = 862 \text{ yards} = \text{distance gun to } b.$$

For the highest point, a, of the trajectory we have, from the condition of the maximum, $0 = tg\varphi - \frac{x^2kg}{V^2} - \frac{xg}{V^2}$, or $x = \frac{-1 + \sqrt{1 + 4tg\varphi\frac{kV^2}{g}}}{2k} = 443$ yards, the corresponding y becomes 8.0 yards, which is the greatest elevation of the shell above the level of the gun; it takes place 12 yards beyond the middle distance from the gun to the point b. To find the angle of impact we differentiate the equation, and obtain

$$\frac{dy}{dx} = tg\alpha = tg\varphi - \frac{xg}{V^2}(1 + xk) = -5°\ 07'.$$

In the absence of any other information, we can assume, without much liability to error, that notwithstanding the loss of velocity arising from the impact, the angle of rebound equals 5° 07′; and taking this value for φ, 544 for x, $0 = y$, we find the corresponding velocity after the first impact,

$$V_1 = \sqrt{\frac{gx(\frac{2}{3}kx + 1)}{2tg\varphi}} = 188,$$

hence, the loss of velocity by the impact,

$$\frac{286 - 188}{286} = 0.34 \text{ parts.}$$

Thus taking a new departure from the point of first impact, the preceding formula apply again to trace out the trajectory to the second impact, and similarly for the next and all following bounds, treated as so many independent level ranges. We have, accordingly, terminal velocity of first bound, 166 yards; initial of the second, 138; hence loss at second impact, 0.17 parts; terminal velocity of second bound, 128 yards; initial of the third, 103; loss by third impact, 0.20 parts; terminal velocity of third bound, 99 yards; initial of fourth, 88; loss by fourth impact, 0.11 parts; and the final velocity with which the projectile plunges into the water, 85 yards a second. The angle of impact and rebound at the second impact is 5° 31′, at the third 5° 47′, at the fourth 6° 00′, and at the last or final disappearance 6° 10′. Greatest elevation of projectile above surface of water in first bound, 12.6 yards, (which takes place 5 yards beyond the middle point of its length;) greatest elevation of second bound, 8.0 yards; of third, 5.0 yards; and of the last, 4 yards. A ball may, therefore, bound over a small vessel sitting low in the water, if midway between the first and second impact, or even between this and the third point of impact. The times of flight of the successive bounds are $3.^s08$, $2.^s46$, $1.^s93$, and $1.^s72$; total, including the first branch of the curve = $13.^s21$. If the time of each bound was observed, or even that of the total flight, allowance could be made for any possible difference in the angle of impact and rebound; should the latter be found smaller, it would be indicated by a shorter flight than the computed one. The vertices of the successive ricochet bounds are nearly tangential to a straight line inclined abou half a degree to the horizon.

APPENDIX No. 22.

REPORT ON THE DETERMINATION OF RANGES OF SHOT FROM 15 AND 20-INCH GUNS. BY CHARLES A. SCHOTT, ASSISTANT UNITED STATES COAST SURVEY.

COAST SURVEY OFFICE, *October* 12, 1864.

SIR: The following statement explains, in general terms, the nature of the inquiry and the operations performed while acting under your instructions, dated September 24, 1864, detailing me for special duty in New York and Boston harbors, to assist General A. P. Howe, inspector of artillery, United States army, in experiments of firing with 15-inch guns. I left Washington September 25, and returned October 9. The instruments used were a small theodolite, with 5-inch horizontal and vertical circles, and a steel band 20 metres in length. The ranges of the ricochet shot were determined as described in my report of July 19. It was found that a plumb-line suspended over the point of observation greatly facilitated the ranging in of the several impacts by the observers. At Fort Richmond, at the Narrows of New York bay, a base line was measured and connected by triangulation with the signals at the gun and the observing station. At the latter point a frame-work was put up, upon which the computed ranges, between 500 and 6,000 yards, were laid off, the line of fire being directed towards the Romer stone beacon. At Governor's island, New York bay, similar measures were taken, with a line of fire directed towards a shot tower on Staten Island. The elevation of the guns above the half-tide level was also determined. In Boston harbor the position of two guns, on Governor's island, and of the observing station at the northeast salient angle of Fort Independence, Castle island, were determined by means of horizontal angles between known objects.

Nine shots were fired from two guns at Fort Richmond, and fifteen from two guns at Governor's island, Boston harbor. The range of the first bound, and the length of several succeeding bounds, as well as the extreme range, were determined. The charge of powder and projectile was varied; also the inclination of the axis of the gun. Results were obtained for the number of ricochets for a given inclination, and for that inclination which produces the maximum number of impacts. Experience was gained of the effect of the waves upon a ricochet shot. Two kinds of powder were tested, and the effect of greater charges of the ordinary (mammoth) powder measured. The recoil of the gun at each fire was noted. A detailed statement of the numerical results was submitted to General A. P. Howe.

On the 26th of October I assisted in determining the ranges of shot from the 20-inch gun mounted at Fort Hamilton, New York bay.

Yours, respectfully,

C. A. SCHOTT,
Assistant U. S. Coast Survey.

J. E. HILGARD, Esq.,
Assistant in charge U. S. Coast Survey Office.

APPENDIX No. 23.

AIDS TO NAVIGATION IN EASTPORT HARBOR AND PENOBSCOT BAY, RECOMMENDED BY ASSISTANT HENRY MITCHELL.

BROOKLINE, MASS., *September* 5, 1864.

DEAR SIR: Under the date of August 11 I had the honor to receive from you instructions to examine certain localities near Penobscot bay and Eastport, and to report upon the necessity of additional buoys or other aids to navigation. Your instructions were accompanied by copies of memorials from the citizens of Rockland, addressed to gentlemen of the board of light-house inspection. These papers I return as requested.

I respectfully recommend that spar buoys be placed upon the following obstructions: Gunning Ledge, Keel Rock, Grindstone Ledge, and Billing's Ledge.

I shall proceed to describe, in detail, the location and character of these dangers, and shall notice other obstructions, which I have examined, and which may hereafter be the subjects of further memorials. As there seems to be no limit to the wants of coasters in the way of buoys, &c., I have endeavored, in the above list, to distinguish the most serious objects of danger from among the great number pressed upon my knowledge.

Herring Gut.—The excellent little harbor of Herring Gut is approached from the sea by three ship channels, the most eastern and least direct of which lies between the Brothers and Mosquito island. The obstacles in this approach are all well marked, with the exception of "Gunning Ledge"—a sunken reef of a very dangerous character. The shallowest and most seaward portion of this reef lies two hundred and thirty metres N. by E. from the northern point of Gunning Rocks, and five hundred and forty metres N.W. by W. ½ W. from the north point of the West Brother island. Five feet, at ordinary low water, covers the portion of this ledge to which I have referred, and its sheltered position usually protects it from breakers; the kelps, however, betray its whereabouts at low tidal stages. The sunken hulls of two vessels are said to be still occasionally seen near this reef when the water is low and clear.

As ships of the largest class seek a harbor in Herring Gut, I recommend that a buoy be placed, not upon the reef itself, but at a distance of one hundred and twenty metres N. by E., where a depth of three fathoms is reached at mean low water. This point lies upon the line between the north point of the West Brother and the light-house of Herring Gut, and is nearly on the sailing course. From this proposed site for the buoy the light-house will bear N.W. ½ W. three-fifths of a mile distant, and the black buoy, which now marks a rock on the opposite side of this channel, N.E. ½ E., one-third of a mile distant.

In the position I have described, I think a buoy will be an aid as well as a protection to navigation.

Within the harbor of Herring Gut there exists a small rock which ought to be marked. It lies on the west side of the anchorage, with the light-house bearing S. ½ E., (about one-third of a mile distant,) and the wind-mill of South St. George bearing N E. It is covered by two feet of water at ordinary low tides, and has about eight feet on either side of it. The three-fathom line of the basin lies within one hundred yards of this object when the tide is out In foggy weather the harbor of Herring Gut is crowded with vessels of all sizes, and in the effort to secure berths in the basin they frequently strike this rock and lose portions of their keels or shoeing. Four *fore foots* of vessels, it is said, now lie on bottom near this rock; I did not see them. This object bears no name that I could learn; but I have referred to it in the preamble of this report as Keel Rock. Its proper marking is much desired by the citizens of South St. George.

My attention was called to the reefs extending into the harbor mouth from the rocky point on which the light-house stands. These reefs form a gradually inclined apron with two extending spurs. As the three-fathom line approaches everywhere within at least a thousand feet of the shore, and as the general aspect of the low rocky point indicates a dangerous approach, I failed to see the importance of further marks.

Comparatively few vessels pass *through* Herring Gut, the exit to the westward being obstructed by bars or shallow spits at the narrows off Alexander island, and by a flat sunken rock lying in the channel-way.

Muscle Ridge Channel.—This channel is one of the most frequented of the so-called *inland communications* along the coast of Maine. It lies within an irregular chain of islands, and extends from White-Head light to Fisherman's island, where it opens upon Penobscot bay. Its most direct approach for vessels from ports to the eastward of the bay is by way of the pass between Fisherman's and Sheep islands; but exaggerated reports of the dangers of this entrance induce many vessels to pursue the more tortuous but more distinctly marked channel under Owl's Head. These dangers consist of the Grindstone Ledge on the south and Sheep Island ledges on the north side of the ample channel-way.

Grindstone Ledge is an isolated rock, awash at low water of spring tides. In quiet weather the sea does not break upon it even at mean low water, but the kelps which grow upon it reveal its position to the observer. Four fathoms of water may be found in all directions within one hundred yards of this object, and upon the north side the same depth may be carried within thirty yards.

This rock lies about four hundred metres from the north shore of Fisherman's island, and may be found at any stage of the tide by the following: *With the double tree on the east end of Fisherman's island bearing S.E. ¼ E., run off till the "Yellow Ledge" is open half way between the aforesaid island and "Marble-Head Rock."* As the rock has a surface of some three hundred square feet, it can scarcely be missed in following these directions. Coasters have the following vague rule for clearing the Grindstone: Keep White-Head light open a hand-spike's length to westward of Otter island. Of course this rule is of no avail in thick weather.

I respectfully offer the opinion that a buoy near this rock would prove a protection to life and property, not only because it would warn vessels from the dangerous object itself, but also because it would reassure them in their apprehension of the Sheep Island ledges, the fear of which is augmented in foggy weather by the roar of their almost incessant breakers. It is not improbable that the rote of these ledges has often driven vessels too far over to the southward, and stranded them upon the Grindstone. With a buoy upon the Grindstone, vessels may boldly run down in foggy weather till they make either this object or the bold shore of Fisherman's island, and thus this direct and ample entrance will lose its present bad name.

Sheep Island Ledges.—By this name are distinguished three rocky spurs which extend from the north side of the entrance. Of these, the middle one terminates in a ragged pile of rocks, some six feet of which are exposed above the plane of low water, and this is the opposing danger to the Grindstone already described. This rocky pile is about three hundred metres from the shore of Sheep island, and very near the three-fathom line of the ship channel.

It appears to me that a buoy upon the Grindstone will obviate the necessity of the several buoys which the adequate marking of the Sheep Island Ledges would require. The channel is so ample that, with security upon the south, no vessels will be likely to venture over to these ledges, and, as far as I can learn, they have rarely been the *immediate* cause of disaster.

Complaint was made to me by the excellent Captain Sleeper, one of the petitioners whose name appears upon the documents enclosed with my instructions, that there is a rock beyond the "Breakwater Ledge," near Owl's Head cove, which frequently brings up coasting vessels. I examined the spot carefully, though not at low water. The ledge is now marked by a spindle, which is intended to indicate the position of this dangerous obstruction at high water. About one hundred feet beyond this spindle the ledge crops out again with but six feet upon its summit at very low tides. Captain Sleeper strongly urges the necessity of a buoy upon this outer rock. With plenty of sea room beyond it, and a very bold shore upon the opposite side of the channel, it would seem but a simple act of carelessness for a vessel to run one hundred feet from a spindle. At high water the outer rock has too much water upon it to fetch up the ordinary class of vessels seeking an anchorage in the cove; and at lower stages of the tide the exposed and ragged form of the ledge warns the stranger to keep his distance and to suspect hidden dangers. Upon this outer rock vessels have frequently lost shoeing and keels.

Billings's Ledge.—This obstacle would scarcely be classed as a danger to navigation, except from its proximity to the landings of the town of Eastport.

Billings's Ledge is a large flat-topped rock, nearly one hundred feet in diameter, which crowns a sandy shoal spot within two hundred yards of Bucknam's Head, (a rocky bluff at the SE. point of the island, upon which Eastport is built.) The shallowest portions of this rock are scarcely covered at the low water of spring, and its red color, as well as its eddies, make it conspicuous until the tide is pretty well up. With the rudest estimate of the distance I have given, it may be found at any stage of the tide by a single range. Bring the lone tree, on the western portion of Bucknam's Head in contact with the corner of Billings's house, (NW.)

This rock, situated almost under the shadow of Bucknam's Head, and approachable by the lead, must be regarded as an insignificant object of apprehension to the careful helmsman. I, however, recommend that a buoy be placed upon it. The great rise of the tides upon the bold shores in the neighborhood makes a very close approach to many of the rocky headlands a matter of safety and perhaps of convenience.

The range of spring tides at Eastport is 21 feet.

The time consumed in my examinations was lengthened by the heavy fogs which prevailed.

Very respectfully yours,

HENRY MITCHELL,
Assistant United States Coast Survey.

Professor A. D. Bache,
Superintendent United States Coast Survey.

APPENDIX No. 24.

Aids to navigation placed or recommended by Coast Survey assistants, and referred for the information of the Light-house Board.

Section.	Object.	Assistants.	Date of report, &c.
I.	Spar buoy on Billings's Ledge, Eastport harbor, Maine.	Assistant H. Mitchell	Recommended to the Light-house Board.
I.	Spar buoy in 3 fathoms N. by E. of Gunning Ledge, Herring Gut harbor, Penobscot bay.	do	Do.
I.	Buoy to mark a rock on the west side of the anchorage in Herring Gut harbor.	do	Do.
I.	Spar buoy near Grindstone Ledge, Muscle Ridge channel, Penobscot bay.	do	Do.
I.	Two buoys in St. George's river, Me.; one to mark the ledge between the western mouth of Herring Gut and Caldwell's island; the other on the ledge making off from Stone Point.	Sub-assistant F. P. Webber	Recommended in report dated December 3, 1864.
II.	Two buoys set to mark the trial course for vessels of the U. S. navy in Raritan bay between Sandy Hook East Beacon, and Prince's Bay light.	Alex. Strausz, acting assistant	For Navy Department, June, 1864.
IV.	The channel in Croatan sound, N. C., buoyed from Pork Point to Croatan light-house.	Sub-assistant J. S. Bradford	For North Atlantic Blockading Squadron, May, 1864.
IV.	Four buoys placed to mark the swash channel and course through Hatteras inlet into Pamplico sound, N. C.	Alex. Strausz and Edward Cordell, acting assistants.	For North Atlantic Blockading Squadron, March, 1864; October, 1864.
IV.	Three buoys set to mark the channel of Neuse river, N. C.	Alex. Strausz, acting assistant	For North Atlantic Blockading Squadron, February, 1864.
IV.	Black buoy No. 3, red buoy No. 4, and black buoy No. 5, at Beaufort entrance, N. C., shifted in position to mark the line of best water found by resurvey.	Edward Cordell and Alexander Strausz, acting assistants.	For North Atlantic Blockading Squadron, April, 1864.
IV.	Three can buoys and numerous stakes set to mark the channel through Core sound and the straits, N. C.	do	For North Atlantic Blockading Squadron, September, 1864.

CONSOLIDATED ALPHABETICAL INDEX

OF THE

TEN ANNUAL COAST SURVEY REPORTS,

FROM 1854 TO 1863, INCLUSIVE.

PREPARED BY SUB-ASSISTANT F. F. NES.

[This Index, with that for this volume, and the Sketch Index, will supply references for all the matter in the Annual Coast Survey Reports published since 1853.]

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1854 :	33d	Congress,	2d	session,	Ex. Doc.	Senate No.	—,	House of	Representatives	No. 20.
1855 :	34th	"	1st	"	"	"	22,	"	"	6.
1856 :	34th	"	3d	"	"	"	12,	"	"	18.
1857 :	35th	"	1st	"	"	"	33,	"	"	—.
1858 :	35th	"	2d	"	"	"	14,	"	"	33.
1859 :	36th	"	1st	"	"	"	—,	"	"	41.
1860 :	36th	"	2d	"	"	"	—,	"	"	14.
1861 :	37th	"	2d	"	"	"	—,	"	"	70.
1862 :	37th	"	3d	"	"	"	—,	"	"	22, 70.
1863 :	38th	"	1st	"	"	"	—,	"	"	11.

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OF

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FROM 1854 TO 1863, INCLUSIVE.

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- 1856: Ditto, embraces Mount Desert and Saunders's Mount, (A.)
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- 1861: Ditto, southern part, secondary triangulation, topography and hydrography, (A *bis.*)
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* Withdrawn: to appear in next annual report.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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